PROCEEDINGS

OF THE

SPECIAL COMMITTEE APPOINTED TO CONSIDER THE MATTER OF THE DEVELOPMENT IN CANADA OF SCIENTIFIC RESEARCH

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[App. No. 5—1919.]

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SPECIAL COMMITTEE ON SCIENTIFIC RESEARCH.

ORDER OF REFERENCE.

HOUSE OF COMMONS,
OTTAWA, April 16, 1919.

Resolved: That in the opinion of this House, it is desirable that a Special Committee be appointed forthwith to consider the matter of the development in Canada of Scientific Research, with power to call for persons, papers and records, to examine witnesses under oath, and to report from time to time.

Attest.

W. B. NORTHRUP,
Clerk of the House.

THURSDAY, April 24, 1919.

Ordered: That the following members do compose the said Committee, viz.: Messrs. Béland, Cronyn, Elkin, Keefer, Kennedy, Lemieux, McCrea, McCurdy, McGibbon (Muskoka), Maclean (Halifax), Nickle, Nicholson (East Algoma), Reid (Mackenzie), Ross, Sheard, Sinclair (Antigonish and Guysborough), Sinclair (Queen's, P.E.I.), Stevens, Thompson (Yukon), Tweedie and Whidden.

Attest.

W. B. NORTHRUP,
Clerk of the House.

WEDNESDAY, May 7, 1919.

Ordered: That the quorum of the said Committee do consist of seven members, and that they be authorized to have their proceedings and such evidence as may be taken printed from day to day for the use of the Committee, and that Rule 74 be suspended in reference thereto.

Attest.

W. B. NORTHRUP,
Clerk of the House.

SPECIAL COMMITTEE ON SCIENTIFIC RESEARCH.

MINUTES OF PROCEEDINGS.

HOUSE OF COMMONS,
TUESDAY, May 6, 1919.

The Special Committee appointed to consider the matter of the development in Canada of Scientific Research met at 10.30 o'clock, a.m.

On motion of Mr. Nickle, Mr. Cronyn was chosen Chairman.

On motion of Mr. Nickle, it was,

Ordered: That a report be made to the House recommending that the quorum of the Committee consist of seven members, and that the Committee be authorized to have its proceedings and such evidence as may be taken printed from day to day for the use of the Committee and that Rule 74 be suspended in reference thereto.

It was at the suggestion of the Chairman decided that Dr. A. B. Macallum, Administrative Chairman of the Advisory Research Council, be requested to attend the next meeting of the Committee.

The Committee then adjourned till Tuesday next the 13th inst., at 10.30 o'clock, a.m.

H. CRONYN,
Chairman.

TUESDAY, May 13, 1919.

The Committee met at 10.30 a.m.

Present: Messrs. Cronyn, Chairman, Elkin, Kennedy, McCurdy, McGibbon (Muskoka), Nickle, Ross, Sheard, Stevens, Thompson (Yukon) and Tweedie.—11.

Dr. A. B. Macallum, Administrative Chairman of the Advisory Research Council, who, at the request of the Committee, was in attendance, gave a resume of the work of the Research Council during the past two years with respect to the recommendations of the Council as to measures to be taken by the Government to provide for industrial research in Canada and especially regarding the foundation of a National Research Institute, which shall have the functions, not only of a bureau of standards, but also of a Mellon Institute, and in which the guilds for research may have a home, and as to the utilization of the lignites of the western plains, etc.

The following documents were produced, viz.:—

Annual report of the Administrative Chairman of the Advisory Research Council of Canada, 1917-1918.

Report of the British Research Council 1915-1916.

Report of the British Research Council 1916-1917.

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Science and Industry.

Trade Guilds for research and the proposed National Research Institute for Canada.

Recommendation of the Research Council with reference to "A Central Institute for Research for Canada," as submitted to the Reconstruction Committee of the Privy Council.

Draft memorandum to Council, in connection with a "National Research Institute for Canada."

National Institute of Scientific Research, Japan.

New Laboratory for Physical and Chemical Research in Japan, and covering letter.

Research Laboratories in Governments—Federal and Provincial, Canadian Universities and Industries. Compiled from information contained in replies to Advisory Research Council.

The Chairman suggested that, with a view of obtaining information in relation to the matters referred for consideration, representatives of universities, scientific associations and Government departments be invited to attend the meetings of the Committee and the following names were accordingly suggested.

H. Mortimer-Lamb, Secretary-Treasurer, Canadian Mining Institute, Rooms 503-504, Drummond Building, Montreal.

J. E. Walsh, General Manager, Canadian Manufacturers' Association, Toronto.

A. L. Dawe, Secretary Pulp and Paper Association, Montreal.

Fraser D. Keith, Secretary Canadian Society of Civil Engineers, 176 Mansfield st., Montreal.

Prof. R. F. Ruttan, M.A., M.D., Director Chemical Laboratories, McGill University, Montreal.

The Committee adjourned until Tuesday, 20th inst., at 10.30 a.m.

H. CRONYN,
Chairman.

TUESDAY, May 20, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Cronyn, Chairman, Béland, Elkin, McGibbon (Muskoka), Nicholson (East Algoma), Reid (Mackenzie), Sheard, Stevens, Thompson (Yukon), and Whidden.—10.

The Minutes of the last meeting were taken as read and confirmed.

The following communications, etc., were submitted by the Chairman, numbers one to eight inclusive being ordered to form part of the record:—

1. Letter from F. C. Morley, Secretary Toronto Board of Trade, Toronto, urging upon the Government the necessity of establishing a research institute.

2. Resolution passed by the Council of the Hamilton Board of Trade, May 1, 1919, urging the establishment of a National Research Institute.

3. Resolution passed by the Port Arthur Board of Trade on the 16th December, 1918, recommending the establishment of a central research bureau.

4. Memorandum to the Government from the Royal Canadian Institute recommending that funds be provided by the Dominion Government to enable the Advisory Council for Scientific Research to carry on its work.

5. Communication from the Managing Secretary of the London, Ontario, Chamber of Commerce, date May 17, 1919, stating that the Directors endorsed the resolution of the Hamilton Board of Trade declaring their support of the establishment by the Government of Canada of a National Research Institute.

6. Resolution passed at the annual general meeting of the Canadian Manufacturers' Association held at Montreal on the 12th and 13th June, 1918, recommending the appointment of manufacturers in representative industries on the Advisory Committee of Scientific Research, etc.

7. Memorandum of joint recommendations drawn up at a meeting held at Ottawa, Friday, November 29, 1918, by representatives of the Trades and Labour Congress of Canada, the Joint Committee on Technical Organizations and the Canadian Manufacturers' Association, presented to the Dominion Government anent scientific and industrial research.

8. Resolution passed by the Canadian Fisheries Association in executive session at Ottawa, May 13, 1919, against the establishment of a central bureau of research.

9. Resolution passed by the Kiwanis Club of Hamilton, Ontario, recommending the establishment by the Government of Canada of a National Research Institute.

10. Minutes of a meeting of Representatives of Labour, The Canadian Manufacturers' Association and the Joint Committee of Technical Organizations held at Ottawa on the 29th November, 1918, anent reconstruction.

11. Letter from J. J. Harpell, President Industrial and Educational Press, requesting to be given an opportunity to appear before the Committee.

12. Letter from G. L. Mattice submitting certain suggestions with respect to the quality and reliability of articles manufactured in Canada.

13. Letter from Andrew T. Drummond submitting certain facts for the information of the Committee *re* industrial research.

The foregoing communications (Nos. 9 to 13 inclusive) were ordered to be filed.

On motion of Mr. Sheard, it was,

Resolved, That Professors W. H. Ellis of Toronto and A. L. Clark of Queen's University, Kingston, Ontario, be invited to attend the meeting of the Committee to be held on 23rd inst.

Dr. A. B. Macallum resumed his address and produced the following papers, viz.: Functions of the proposed National Research Institute and Bill to promote scientific and industrial research in the States, Territories and the District of Columbia with institutions of higher education.

Dr. R. F. Ruttan who, at the request of the Committee was in attendance, addressed the Committee in relation to the development of scientific research in Canada.

On motion of Mr. Whidden, it was,

Resolved, That the undermentioned be heard at to-morrow's meeting, viz.: Dr. Ruttan, Dr. A. S. Mackenzie, Dr. McLaurin and Dr. Murray.

On motion of Mr. Stevens, it was,

Resolved, That the undermentioned American Technologists who have given attention to the question of scientific and industrial research in the United States be invited to appear before the Committee, viz.:—

Col. J. J. Carty, Electrical Engineer, 15 Dey St., New York.

Dr. F. B. Jewett, Chief Engineer, The Western Electric Co., 463 West St., New York.

Dr. S. W. Stratton, Bureau of Standards, Washington, D.C.

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Prof. Geo. B. Hale, President of the National Research Council of the United States, Washington, D.C.

W. A. Hamor, Assistant Director Mellon Institute of Industrial Research. Pittsburgh, Pa.

The Committee adjourned till to-morrow (Wednesday) at 10 o'clock.

H. CRONYN,
Chairman.

WEDNESDAY, May 21, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs, Cronyn, Chairman, McGibbon (Muskoka), Nicholson (East Algoma), Thompson (Yukon), Tweedie and Whidden.—7.

The minutes of the previous meeting were taken as read and confirmed.

Dr. R. F. Ruttan resumed his address.

Dr. A. S. Mackenzie, President of the University of Dalhousie, Halifax, N.S., Prof. R. D. McLaurin of the University of Saskatchewan, Saskatoon, Sask., and Prof. J. C. McLennan of Toronto addressed the Committee in relation to the matters under consideration.

The Committee adjourned until Friday, 23rd inst., at 10.30 o'clock, a.m.

H. CRONYN,
Chairman.

FRIDAY, May 23, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Cronyn, Chairman, McGibbon (Muskoka), Nickle, Nicholson (East Algoma), Sheard, Thompson, Tweedie.—7.

The minutes of the previous meeting were read and confirmed.

The following addressed the Committee in relation to the matters under consideration, viz.:—

Prof. A. L. Clark, Queen's University, Kingston, Ontario.

Prof. Dayton C. Miller, School of Applied Science, Cleveland, U.S.

The Committee then adjourned till Wednesday, June 4, at 10.30 o'clock, a.m.

H. CRONYN,
Chairman.

WEDNESDAY, June 4, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Cronyn, Chairman, McCurdy, Nickle, Ross, Sheard, Thompson (Yukon) and Whidden.—7.

The minutes of the previous meeting were read and confirmed.

The Chairman submitted resolutions adopted by the undermentioned advocating the establishment in Canada of a National Research Institute, all of which were ordered to be filed:—

Montreal Board of Trade, Montreal.
Canadian Club, Fort William, Ontario.
Board of Trade, Saskatoon, Sask.
Kitchener Public School Board, Kitchener, Ont.
St. John Board of Trade, St. John, N.B.
Board of Trade, Orillia, Ont.
Board of Trade, St. Thomas, Ont.
Canadian Club, Chatham, Ont.
Women's Canadian Club, Hamilton, Ont.
Victoria Board of Trade, Victoria, B.C.
The Engineering Institute of Canada, Hamilton, Ont.

The Chairman communicated contents of letters received from Messrs. W. A. Hamor, Assistant Director, Mellon Institute, Pittsburgh, Pa., and Dr. S. W. Stratton, Bureau of Standards, Washington, D.C., accepting the invitation extended to them to address the Committee on Friday 6th and 13th inst. respectively.

On motion of Mr. Nickle, it was,

Ordered, That the Clerk of the Committee be instructed to ask the Canadian Fisheries Association whether they desired to be heard before the Committee.

On motion of Mr. Nickle, it was,

Ordered, That W. R. Whitney, Director Research Laboratories, General Electric Co., Schenectady, N.Y., be invited to address the Committee.

On motion of Mr. Thompson, it was,

Ordered, That the Clerk of the Committee be instructed to request the attendance before the Committee of the Chairman of the Biological Board, Naval Department, Assistant Director Experimental Farms and Dominion Chemist and Dominion Cerealist.

Professor W. Lash Miller, of the University of Toronto, addressed the Committee and submitted the following for the use of the Committee, viz.:—

Report of the General Committee of Chemical and Allied Societies *re* question of publishing chemical bibliographies in the English language, (30th January, 1919).

Resolution adopted at the annual meeting of the Royal Society of Canada urging upon the Government of Canada the establishment of a Dominion laboratory for scientific measurements similar to the Bureau of Standards, etc.

Annual Report of the Society of Chemical Industry—Canadian Section—1917-1918.

Chemistry and Agriculture.

University of Toronto studies.

The University of Toronto Monthly (Scientific number).

Canadian Chemical Research Applied to Agriculture and Forest Products.

Chemical Industry in Canada during the war.

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The Chemists of Canada.

Chemical Industry in Canada (Industrial Alcohol).

Chemical Industry, some applications of chemistry to industrial processes.

Chemical Industry, Foods—The chemical control of the preparation and sale of foodstuffs.

Journal of the Society of Chemical Industry (1919).

The Committee adjourned till Friday next, the 6th inst., at 10.30 o'clock, a.m.

H. CRONYN,
Chairman.

FRIDAY, June 6, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Cronyn, Chairman, McCurdy, McGibbon (Muskoka), Nickle, Ross, Sheard and Thompson (Yukon).—7.

The minutes of the previous meeting were taken as read and confirmed.

The Chairman read the following communications, viz.:—

From George B. Hale, Honorary Chairman of the National Research Council, Washington, D.C., regretting his inability to appear before the Committee.

From Fraser S. Keith, Secretary, Engineering Institute of Canada, advocating the need of industrial research in Canada and submitting, for the consideration of the Committee, certain suggestions in connection with the above question.

W. A. Hamor, Assistant Director, Mellon Institute, Pittsburgh, Pa., and G. M. Murray, Ottawa, Representative Canadian Manufacturers' Association addressed the Committee in relation to the matters under consideration.

The Committee adjourned till Wednesday the 11th inst., at 10.30 o'clock, a.m.

H. CRONYN,
Chairman.

WEDNESDAY, June 11, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Cronyn, Chairman, Nickle, McGibbon (Muskoka), Ross, Sinclair (Queen's, P.E.I.), Stevens, Thompson (Yukon) and Whidden.—8.

The minutes of the previous meeting were read and confirmed.

The Chairman read the following communications, viz.:—

From W. R. Whitney, Director Research Laboratories, General Electric Co., Schenectady, N.Y., regretting his inability to appear before the Committee.

From the Secretary of the Kiwanis Club of Brandon, Man., and the Secretary-Treasurer Board of School Trustees, New Westminster, B.C., transmitting resolutions endorsing the establishment in Canada of a National Research Institute, and

From the Secretary-Treasurer, Canadian Institute of Chemistry, Montreal, tendering to proposed Advisory Committee the services of representatives of their newly formed institute.

The Clerk of the Committee was instructed to acknowledge the receipt of the foregoing communication stating it is not contemplated appointing an Advisory Committee.

On motion of Mr. Nickle, it was,

Resolved, That Mr. Thompson (Yukon) replace the permanent chairman during the latters absence.

The undermentioned addressed the Committee in relation to the matter under consideration, viz.:—

F. T. Shutt, Assistant Director, Experimental Farms and Dominion Chemist.

C. E. Saunders, Dominion Cerealist, and

Professor Prince, Chairman Biological Board, Naval Department.

The Committee adjourned until Friday, the 13th inst., at 10.30 o'clock, a.m.

ALFRED THOMPSON,
Chairman, pro-tem.

FRIDAY, June 13, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Thompson (Yukon), Chairman pro tem, Elkin, Nickle, McCurdy, McGibbon (Muskoka), Ross and Sheard.—7.

The minutes of the previous meeting were taken as read and confirmed.

Dr. S. W. Stratton, Director Bureau of Standards, Washington, D.C., who addressed the Committee, gave a comprehensive outline of the various activities and phases of work conducted at the Bureau.

The Committee adjourned to the call of the Chair.

H. CRONYN,
Chairman.

TUESDAY, July 1, 1919.

The Committee met at 10.30 o'clock, a.m.

Present: Messrs. Cronyn, Chairman, McGibbon (Muskoka), Nickle, Sheard, Thompson (Yukon), Tweedie and Whidden.—7.

The minutes of the previous meeting were read and confirmed.

The following communications, etc., received, were read and ordered to be filed, viz.:—

Letter from the President of the University of Manitoba, Winnipeg, Man., pointing out the advantages to be secured by mobilizing the universities in behalf of scientific and industrial research.

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Letter from the President of the University of Saskatchewan, Saskatoon, Sask., advocating the establishment of a Central Institute for Research.

Resolution from the Secretary of the Rotary Club, Hamilton, Ontario, urging the establishment of a National Research Institute.

Letter from the Secretary Canadian Mining Association, suggesting that in the event of the establishment of a research institute provision be made for the avoidance of any encroachment with the research work now being carried on by the Federal Department of Mines.

Resolutions passed by the Board of Trade of Quebec, Medicine Hat, Manitoba, and Toronto School Boards, endorsing the proposal to establish a National Research Institute for Canada.

On motion of Mr. Nickle, it was

Resolved, That the following draft report be adopted and presented to the House as the Second Report of the Committee.

TUESDAY, July 1, 1919.

The Special Committee appointed to consider the matter of development in Canada of Scientific Research, beg leave to present the following as their Second Report:—

During the course of their inquiry your Committee held nine sittings and heard some fifteen witnesses, among whom were men eminent throughout this continent for scientific knowledge and attainments. Your Committee also received and considered a number of resolutions and communications addressed to them by Boards of Trade, Associations, etc., and as well had placed before them a copious supply of addresses and official reports dealing with the subject, issued in this and other countries. After hearing the said witnesses, and upon consideration of the whole question, your Committee beg to report that Scientific Research in Canada requires and deserves generous encouragement and financial support from the Dominion Government. In no better way can the natural resources of our country be made available with the same degree of celerity and certainty, nor can our native industries achieve their proper position in the markets of the world unless given the advantages accruing from scientific research and discovery.

Those great industrial nations, Great Britain, the United States and Germany, for many years have recognized the need of national research and have aided the same by large grants of public moneys. Two, at least, of the three countries mentioned are to-day expending vastly increased sums towards that end, while other nations, including France, Japan and our sister Dominions, are preparing to take action along similar lines.

In Canada the Dominion Government some time ago, through the scientific branches of its various departments entered upon the field of scientific research. Under the sanction of the Research Council Act of 1917 and by means of the Honorary Advisory Council for Scientific and Industrial Research appointed thereunder, a preliminary and highly necessary survey of the above field has been made. Assistance has also been afforded through this body to a comparatively limited number of scientific investigations.

Your Committee feel that the time has arrived when further steps must be taken and additional financial support be available if this country desires to make a proper use of its potential assets and to attain or maintain its standing in the commonwealth of nations.

The attention of your Committee has been directed to the fact that there does not exist in this country any institution corresponding to the Bureau of Standards at Washington. As a result, Canada is dependent on the neighbouring republic or on other countries for information and guidance in matters which vitally concern her industries. A study of the evidence submitted will convince any impartial student of the weakness of our position in this regard and of the need for a speedy remedy. Your Committee, therefore, recommend to the consideration of the Government the establishment of a Dominion Bureau of Standards.

Your Committee further recommend that concerted and continued efforts be made to place before the people of Canada the facts regarding scientific research and the far-reaching advantages to be derived from national support thereto. It is plain that outside of a limited circle even the best informed and most influential citizens are sadly lacking in knowledge on this important subject.

While your Committee, as above stated, are unanimous as to the need of co-operation and national support of Scientific Research, yet a majority of its members, owing to the lack of time and pressure of other parliamentary duties, feel they have been unable to so consider and digest the evidence adduced and the other material brought to their attention as to advise the House at this time what may be the best methods of aiding and encouraging Scientific Research throughout Canada.

Your Committee would therefore recommend that the Committee should be re-appointed as early as possible next session to give further consideration to this matter, and to prepare to the House for consideration proposals dealing therewith.

Your Committee further recommend that their proceedings submitted herewith be printed forthwith for distribution, and be also printed in the appendix to the Journals of this session and that Rule 74 in relation thereto, be suspended.

All which is respectfully submitted.

H. CRONYN,
Chairman.

The Committee then adjourned *sine die.*

Attest

L. C. PANET,
Clerk of Committee.

PROCEEDINGS.

HOUSE OF COMMONS,
OTTAWA, May 13, 1919.

The Special Committee appointed to consider the matter of the development in Canada of Scientific Research met at 10.30 a.m., Mr. Cronyn, Chairman, presiding.

The CHAIRMAN: Dr. Macallum is here: he is Chairman of the Honorary Advisory Council and perhaps we can hear from him now.

Mr. SHEARD: I think that before we hear from Dr. Macallum, as unfortunately I was unable to be present at the organization meeting, I may say that, personally, I appreciate very much the opportunity of hearing something of the inside of his work, because he is a scientist whom I have known for upwards of twenty years, and I know something of his ability and standing in this Dominion. Probably some members of the Committee are not so thoroughly acquainted with his life-work in various branches of science as I am. He has occupied a position of distinction here for many years, I think for some eighteen years, as Fellow of the Royal Society of England, a distinction which among scientific men in the British Empire is unequalled and unsurpassed. Personally, I was more than gratified when I knew that the Government was going to avail itself of his scientific attainments in order to promote scientific research in the Dominion. I am certain there is not a member of this Committee who will not be desirous of co-operation and assisting him in his efforts. So far as I am concerned, I shall endeavour to assist him to the utmost of my ability. Whilst I believe that this Committee lapses with the present session of Parliament, I feel there will be more or less disjointed work unless some attempt is made to continue the service. How far that can be accomplished I am not in a position to say, but if there was a committee of Parliament that could continue the work of co-operation we could lay the foundation of an enormous beneficial service to the industries of this country along the lines of what was done during the past thirty-five or forty years in Germany, where in many industrial works they revolutionized industrial pursuits and practice, largely as the result of the work of chemists, biological chemists and physicists, with the result that prior to the war, when Germany was not in disfavour, as she is to-day, she was looked upon as the great pioneer in scientific work, achievement and advancement. We all know how we used to look to them for the finishing touches. That has been changed now. We have a new interpretation of their ideals, with which we do not conform; but still we must recognize the value of the scientific work which she did in Europe, and in my judgment, it is time that Canada should adopt some practical methods of attaining the same object.

The CHAIRMAN: Perhaps we had better have the order of reference read.

The CLERK (reads):—

> "That, in the opinion of this House, it is desirable that a Special Committee be appointed forthwith to consider the matter of the development in Canada of Scientific Research, with power to call for persons, papers, and records, to examine witnesses under oath, and to report from time to time."

The CHAIRMAN: Perhaps Dr. Macallum could inform the Committee of the inception of this movement, and explain to us how far it has developed up to the present time, and then he might answer any questions which the members of the Committee desire to ask.

Dr. A. B. MACALLUM: Mr. Chairman and gentlemen, members of the Committee, the Council of which I am chairman was appointed on November 28 to December 3,

1916, one member, Mr. Surveyer, of Montreal, consulting engineer, having been appointed on December 28. The Order in Council, by which the appointments were made, was passed on June 16, 1916, and a copy of this Order in Council is contained in my report of last year. It is given in Appendix E to the report. The appointments were, therefore, made six months after the passage of the Order in Council. The Order in Council laid down a certain number of functions. They were:—

"(a) To consult with all responsible bodies and persons carrying on scientific and industrial research work in Canada with a veiw to bringing about united effort and mutual co-operation in solving the various problems and industrial research which, from time to time, present themselves;

"(b) To co-ordinate as far as possible the work so carried on so as to avoid overlapping of effort and to direct the various problems requiring solution into the hands of those whose equipment and ability are best adapted thereto;

"(c) To select the most practical and pressing problems indicated by industrial necessities and present them, when approved by the Committee, to the research bodies for earliest possible solution.

"(d) To report, from time to time, the progress and results of their work to the Minister of Trade and Commerce as Chairman of the Committee of Council."

These were the functions, and more briefly they were indicated in a rescript addressed by the Minister of Trade and Commerce to the Council. A copy of this rescript is contained in a pamphlet which was issued for general distribution, and which I may pass around among the members. It sets forth that the Advisory Council, by direction of the Chairman of the Sub-Committee of the Privy Council has been charged with the following duties:—

"(a) To ascertain and tabulate the various agencies in Canada which are now carrying on scientific and industrial research in the universities and colleges, in the various laboratories of the Government, in business organizations and industries, in scientific associations or by private or associated investigators.

"(b) To note and schedule the lines of research or investigation that are being pursued by each such agency, their facilities and equipment therefor, the possibilities of extension, and particularly to ascertain the scientific man-power available for research and the necessity of adding thereto.

"(c) To co-ordinate these agencies so as to prevent overlapping of effort, to induce co-operation and team work, and to bring about a community of interest, knowledge and mutual helpfulness between each other.

"(d) To make themselves acquainted with the problems of a technical and scientific nature that are met with by our productive and industrial interests, and to bring them into contact with the proper research agencies for solving these problems, and thus link up the resources of science with the labour and capital employed in production so as to bring about the best possible economic results.

"(e) To make a scientific study of our common unused resources, the waste and by-products of our farms, forests, fisheries and industries, with a view to their utilization in new or subsidiary processes of manufacture, and thus contribute to the wealth and employment of our people.

"(f) To study the ways and means by which the present small number of competent and trained research men can be added to from the students and graduates of science in our universities and colleges, and to bring about in the common interest more complete co-operation between the industrial and productive interests of the country and the teaching centres and forces of science and research.

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(g) To inform and stimulate the public mind in regard to the importance and utility of applying the results of scientific and industrial research to the processes of production by means of addresses to business and industrial bodies, by the publication of bulletins and monographs, and such other methods as may seem advisable."

You will note that all the functions are advisory towards the Government. The Committee investigates the conditions and ascertains what is to be done; it makes recommendations to the Government, it does not necessarily carry on scientific work itself, in fact a small body consisting of eleven men would find it impossible to indulge in scientific work which would achieve any result in such a wide field in a number of years. Later, as the Council developed its work it found that to make things stable, to give a certain amount of security and definiteness to its work, it was necessary to have a statute enacted and this statute, assented to on August 29, 1917, gave the following functions to the Council:—

"The Council shall have charge of all matters affecting scientific and industrial research in Canada which may be assigned to it by the sub-committee, and shall have the duty of advising the sub-committee on questions of scientific and technological matters affecting the expansion of Canadian industries for the utilization of natural resources of Canada."

The Council, by this Act, is to consist of not more than eleven members, "Who shall be appointed by the Governor in Council on the recommendation of the Sub-Committee of the Privy Council on Industrial and Scientific Research, hereinafter called 'the Sub-Committee'". That is the number that now constitutes the Committee. The Committee itself is composed of the following gentlemen: F. D. Adams, Ph.D., LL.D., F.R.S., Dean, Faculty of Applied Science, McGill University, Montreal, . . .

Mr. ELKIN: Who are these? Are they the Sub-Committee of the Council?

Dr. MACALLUM: No, the Sub-Committee of the Council consists of four members of the Cabinet; there were six members originally, but since they abolished the Inland Revenue there are now five: The Minister of Trade and Commerce who is Chairman, the Minister of the Interior, the Minister of Mines, the Minister of Labour and the Minister of Agriculture. The members of the Council were: the Administrative Chairman, F. D. Adams, Ph.D., LL.D., F.R.S., Dean, Faculty of Applied Science, McGill University, Montreal; T. Bienvenue, Esq., Vice-President and General Manager, La Banque Provinciale du Canada, Montreal; R. Hobson, Esq., President, Steel Company of Canada, Hamilton; S. F. Kirkpatrick, M.Sc., Professor of Metallurgy, Queen's University, Kingston, Ont.; J. C. McLennan, Ph.D., F.R.S., Professor of Physics and Director of the Physics Laboratory, University of Toronto, Toronto; A. S. Mackenzie, Ph.D., D.C.L., President, Dalhousie University, Halifax, N.S.; W. C. Murray, M.A., LL.D., President, University of Saskatchewan, Saskatoon, Sask., R. A. Ross, Esq., E.E. (Tor.), N. Can Soc. C.E., Consulting Engineer, 80 St. Francois Xavier st., Montreal; R. F. Ruttan, M.A., M.D., Sc. D., Professor of Chemistry and Director of the Chemical Laboratories, McGill University, Montreal; Arthur Surveyer, B.A., Sc., M. Can. Soc., C.E., Consulting Engineer, 274 Beaver Hall Hill, Montreal. Professor Kirkpatrick resigned last year and Mr. Tancreed Bienvenue resigned also about three months ago, and in the place of Professor Kirkpatrick, Professor W. L. Goodwin, Dean of the School of Mines, Queen's University, Kingston, and in place of Mr. Bienvenue, Sir George Garneau, President of Garneau, Limited, and Professor of Chemistry of Laval University, a Civil Engineer by profession, were appointed. That is the composition of the Committee at present. It has held twenty-three meetings in the last two years, each meeting usually continuing from two to four days, except once when there was an emergency meeting of one day, held in Montreal.

[Dr. A. B. Macallum.]

Now the Committee took itself, I might say, pretty seriously, from the first. It started in to fulfill the duties imposed upon it by the Order in Council, and one of the very first things it did was to determine the status of scientific and industrial research in Canada. Now for the majority of the Committee it was a virgin field; for myself, as a result of thirty-four years' connection with research in Canada, it was not a new undertaking by any means. Moreover, before I was appointed Chairman of the Research Council I was Chairman of the Board of Graduate Studies of the University of Toronto for two years, a position which I resigned when I was appointed to this position. I was also, from 1914 to 1916, Chairman of the Committee on Graduate Studies of the Canadian Universities' Conference. The experience acquired in these positions enabled me to understand the research situation in Canada. To get a census of industrial research in Canada, the Research Council issued a series of questionnaires, one to all the industries, one to all the Universities, a third to the scientific departments of the Government and a fourth to the technical societies of the Dominion. There is a bound copy here of all the four questionnaires. Questionnaire No. 1 was sent to about eight thousand firms; of course many of these were not perhaps worth while approaching on this score, but they were appealed on the chance of furnishing information of value. We received answers from about two thousand eight hundred of these eight thousand firms, and we have summarized the essentials of those answers. We got answers also from the various scientific departments of the universities, from the technical societies and from the scientific departments of the Government. The results that we obtained were certainly not very encouraging, I mean to the general members of the committee; to myself it was not a very great surprise. I know what the situation in this country is; I have referred often to it publicly, in the years from 1896 to 1912, and especially in my position as Chairman of the Board of Graduate Studies of the University of Toronto. Now the situation as it revealed itself in the industries is practically as follows: Only about thirty-seven firms in this Dominion appear to have research laboratories, the majority of these have, each, only one research man employed. There are about seven or eight that employ four or more, something like four that employ two or three, and in some of them the work is purely routine, for although called research, it is not research at all, it is simply making analyses of raw materials to ascertain whether they are up to standard. You can get men qualified for routine work much more cheaply than you can get men qualified for research work. Let me emphasize here the point that the profession of research men is the most highly specialized in the world. There is no profession in which there is such a great degree of specialization. The man who is doing research along his own particular line knows more about that line of work than anybody else in the world, and, therefore, he is a specialist. If he is energetic, enthusiastic and productive, he cannot be obtained at a salary of from twelve hundred to two thousand dollars. It is utterly impossible to obtain him for any such figure, and in a certain number of these routine laboratories, which are called research laboratories, the so-called research men are only routine men. In this country there are not many more than fifty pure research men all told. I know it is not pleasant for me to say this, but it is a fact, nevertheless. Now, what is the situation in this respect in the United States or Germany?

Mr. THOMPSON (Yukon): Would you be good enough to give us the line of demarcation between a purely research man and a routine man, as you have it in your mind?

Dr. MACALLUM: A routine man is employed merely to determine the ordinary qualities of the materials that come before him in a chemical laboratory.

Mr. STEVENS: Testing in steel works, etc.?

Dr. MACALLUM: Yes. A research man plunges into the unknown field. He does not content himself with the ordinary things that are before him, or with the knowledge that is already available. He wants to add to that, and he starts out on his own

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line, a line determined by his taste and intellectual make-up, and persists along this line, and makes it his own. He is a man, so to speak, *sui generis*, and the great research man will make himself such in spite of everything. Faraday was a laboratory attendant in the Royal Institution when Sir Humphrey Davy was lecturing there. He eventually became laboratory assistant, and as such he proceeded to make experiments for himself. You all know what the result was. The great development in electrical science of to-day is due to the discoveries of Faraday. His achievements were due to his make-up. He could never have been routine man. It would have been impossible. I say that in order to make the distinction between the mental make-up of a routine man and a research man. We found also that the university was not producing research men. I knew that of course. The degree of doctor of philosophy was first instituted in Canada in the University of Toronto, in 1896, and in McGill University, about 1904. That is the degree that is given essentially for research. It is the essential requirement for the degree in the German universities. It was given for research in the United States from 1876 onward. In the last twenty-three years these two Canadian universities have only graduated eighteen for this degree, of which eleven were in pure science. Those are the only two universities that give the doctor of philosophy degree in Canada. In the United States the number of Doctors of Philosophy graduated every year is very large. There are ten universities which turn out somewhere between 350 and 500 annually. We in Canada only turned out 11 in 23 years. Of course, that does not reveal the whole situation. The students of our universities go to the United States to get their degree, because there is a great deal of prestige attached to the American universities, especially Harvard, Yale, Columbia, Johns Hopkins, Princeton, Cornell, Chicago, Wisconsin and the University of California. These universities are the wealthiest in the world. There are no other universities like them. Before the war Harvard's annual expenditure was $2,400,000, Columbia's, $4,600,000. Yale has an income of about $2,300,000, Chicago spends about $2,000,000. The university in Canada today with the largest income is Toronto University, and it is only getting about $900,000 from all sources. McGill has about $600,000 and Queen's comes next. This explains the situation as regards research in Canada. We have not got enough scientific men to carry on the work. We might bring back those who went to the United States and who have achieved distinction there. There are workers like Dr. Dushman of the General Electric, Schenectady, men who ought to be back in this country, but who cannot come back because of the low salaries or poor inducements held out in Canada. I have here a summary of all the information that we gathered from those questionnaires.

Mr. NICKLE: Which is cause and which is effect? Is it the lack of demand by the establishments, or the lack of supply from the universities that makes so little research work in Canada?

Dr. MACALLUM: The situation in the universities, as I view it, is due to the fact that they have hitherto been controlled by men who are not scientific men, whose training was mainly along the classical or literary lines. That was not the case in the United States in a number of notable instances. From 1876 to 1902 Johns Hopkins was under the presidency of Dr. Gilman, who was keenly appreciative of the value of scientific research and he was succeeded by Dr. Remsen who had been a professor of chemistry and who is still to-day in his old age one of the most active research workers in the United States. Harvard was for thirty-five years under President Elliot, who had been a professor of chemistry. I need not enlarge on this; but that shows you the difference in the factors operating in the United States and Canada. Now, I do not say this in condemnation of the governing bodies, or the presidents of our Canadian universities, because you cannot expect them to appreciate what scientific research is or what it will do, and further, they have the conservative forces of their environment to contend with. There was also public indifference, which, how-

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ever. could have been overcome by education. A crusade for research was carried on for years in the University of Toronto. Attention was called again and again to the need of research in science, but such efforts were largely unsuccessful. The same thing was done in McGill and in Dalhousie and other universities. To-day the situation is different. Further, there are men like President McKenzie, of Dalhousie, who was a distinguished researcher in physics before he was appointed president of that university. President Murray, of Saskatchewan, is keenly interested in agricultural research and does everything he can to promote it. The future is suspicious for McGill under her new presidency. Sir Auckland Geddes is a scientific man first and foremost. I should expect that the situation will henceforth change in our universities, but not very rapidly for a university environment is very conservative. I recall that when I first began to advocate the promotion of research in the University of Toronto, both inside and outside of the university I met with ridicule. All the staff on the literary side were pointing to Oxford as the model for the university to follow, not an American university, and contempt was poured on the word "research." What was research, they asked. We had to meet that attitude. If the universities had been alive in the past to what was absolutely necessary in this direction, I think the public would have appreciated it.

Mr. McGIBBON: The initiative must come from the universities.

Dr. MACALLUM: Yes, in scientific research.

Mr. NICKLE: You think that if the universities had produced the men the industries would have absorbed them?

Dr. MACALLUM: Certainly.

Mr. NICKLE: So that it is the universities' lack of appreciation that led to the small number of men being employed by the industries?

Dr. MACALLUM: Yes.

Mr. THOMPSON: Is it not based upon the old English idea of science?

Dr. MACALLUM: That is quite true. The men who come from the English universities to Canadian universities carried with them to their new posts the old idea.

Mr. SHEARD: I think Cambridge is an exception. Professor Foster's work is famous. There was a very excellent department of research there. I had the pleasure of taking three sessions there.

Dr. MACALLUM: You are quite right, that is an exception. There were certain departments in Cambridge, for instance, physiology, bio-chemistry, physics, which were distinguished for research.

Mr. SHEARD: Some eminent scientists came from Cambridge to the United States. Some of them are at the Johns Hopkins University.

Dr. MACALLUM: One cannot make a sweeping generalization. I am looking at the whole effect. Those men at Cambridge had to fight against forces that were overwhelming in their influence. For example, Professor Foster, on one occasion, said that if it was not for Mr. Coutts Trotter, who, though a literary man, was appreciative of what science would do for the university, and who insisted upon the colleges contributing to the laboratories—if it had not been for his assistance research would not have found a home in Cambridge. To-day, of course, the old forces are not silent, though they recognize that a new era has begun. They have kept us behind. It is not so in the United States. The universities there are the greatest and wealthiest in the world. There are no other universities like them, so far as resources are concerned, not even the University of Berlin. In those universities there is the spirit of research. It may be feeble in some instances, but in others it is of significant value, and they are all aiming at producing research men. It is because of this situation that the United States has got so many research men to-day.

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Mr. NICKLE: Do you think that the fact of our universities being relatively small, as compared with the American universities, made our manufacturers loth to pay adequate remuneration for pure research, and, therefore, that men were not inclined to go into research work in the universities, believing that it would be difficult to obtain employment in Canada after graduation?

Dr. MACALLUM: To a certain extent, that is true; but the universities should have educated the public as to the need for research. I do not think that the industries would have been slow in accommodating themselves to the situation which now faces us.

Mr. MCGIBBON: There is an industry in my little town which spent $25,000 in five years for research.

Mr. SHEARD: I do not think that the industries can be expected to secure research men. It is the university that develops the men, and the industry may see the value of their work in a sense; but the university will have to be endowed to encourage these men in research work, for they are pioneers in a new field.

Mr. NICKLE: That is not the way they did in Germany.

Dr. MACALLUM: Of course, it depends on the spirit of the universities. If a university is endowed with the spirit of enthusiasm in research, you are going to get your research men. I know from my own experience. The biological and physiological departments of the University of Toronto for a number of years stimulated a number of workers, and since the nineties they produced the professor of zoology, the professor of anatomy in Chicago University, one of the professors of botany in Harvard, and the professor of medicine in Jefferson and others. They trained also Dr. John McCrae, who died in Flanders over a year ago. A dozen of such outstanding men could be named. At that time there was an enthusiasm for the work, and the students went into it ignoring the gains which they might have if they went into a profession; they continued their researches for years.

Mr. SHEARD: The university gave them the interest.

Dr. MACALLUM: Yes. If the universities had promoted and encouraged research as a whole, we would have been far forward to-day. There would have been more money coming to them from the public; that is, the public would have been appreciative, and it would have been less difficult to get larger endowments.

The CHAIRMAN: When this discussion commenced I think you were going on from the example of the United States to the example of Germany.

Mr. ELKIN: Is it not a fact that the appointments in Germany, for men who carry on industrial and scientific research, were a great stimulus to the students of the German universities to continue that line of work, knowing that when they came out there would be fairly remunerative positions in the different industries.

Dr. MACALLUM: That was true latterly, but not at first. In the late seventies it was the universities that were producing the scientific men, but going into the industries they showed how valuable they could be to them. The universities were producing more men than they could find places for in the university. You know in the German universities there are 2,000 professors and instructors in the scientific departments. These positions are very valuable indeed, and the number of students who qualified for them was so great, that the surplus had to go out into the industries. When they did go out into the industries they showed their employers how valuable they were.

Mr. MCCURDY: Some steps have been taken, have they not, to interest the Canadian universities in the work of your board? I notice last November or December some specific recommendations were made in that respect.

Dr. MACALLUM: I am coming to that later, Mr. McCurdy.

Mr. MCCURDY: What relation has the biological board to your body?

Dr. MACALLUM: It is an independent body, I have been secretary-treasurer of it for eight years; but we are trying to bring it into close relation with the Administrative Council of which I am chairman.

Mr. NICKLE: There was a difference between the ideals. With the German university the ideal was efficiency rather than culture; whereas the English ideal was that culture was the essential.

Dr. MACALLUM: As a matter of fact both ideals were fundamentally alike, although in the German ideal efficiency was emphasized. The German universities are under official or governmental control and hence their tendencies, but culture was not disregarded. The term was seized and misused by the official classes.

Mr. NICKLE: Seized on what term? I have understood that the German universities attach more importance to efficiency in science and the turning of their knowledge into wealth than did the English university. The English universities on the other hand, attach more importance to culture.

Dr. MACALLUM: That might be true with regard to some branches of science, but not for all. Take physiology and biology, for instance some of the greatest biologists in the last 30 years were German, as were some of the greatest physiologists; and this is also the case with regard to chemistry. In chemistry there are tremendous opportunities that industry is now grasping; but for 25 years it was a subject that lacked organized and consistent attention. I have been to Germany a great many times, and I know about 300 scientific men in the universities of Germany. While I do not admit their superiority, they do possess the scientific spirit. Of course they know that eventually they would get public recognition; and they did get public recognition because they continued their work. A Professorship in a German university was more esteemed than a knighthood, a baronetage, or even peerage.

The CHAIRMAN: I do not want in any way to control the Committee, but I suggest that we allow Doctor Macallum to complete his statement and if necessary he can be heard again, and that we defer all these questions unless there is some point we want to elaborate.

Mr. ELKIN: There is one point I would like to have brought out. This is a committee of the House and there are some other committees, where do these committees all interlock?

Dr. MACALLUM: The Sub-Committee of the Privy Council is the final authority. Of course it is subject to the Cabinet. So far as the Research Council is concerned, none of our recommendations go into effect until they are approved by the Sub-Committee of the Cabinet. We are a recommending and advisory body.

Mr. NICKLE: You are Chairman of the Scientific Committee and the Sub-Committee of the Council is the political committee that links the Government up to the Council.

Dr. MACALLUM: The governing body, I would not say political.

Mr. NICKLE: I mean the political body as distinguished from the scientific.

Dr. MACALLUM: Yes, if accepted in that sense.

The CHAIRMAN: Then this committee, as I take it, is a committee which the Government and the House asked to investigate the work of the Scientific and Advisory Council and report to the House on the recommendations which this Advisory Council have already made or might make and to recommend any further steps which we think should be taken.

Dr. MACALLUM: Now, the situation which I have just referred to in the universities, the lack of scientific men in the country who are qualified to take up research work came up very early for consideration by the Research Council and in consequence

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it established studentships and fellowships. Each studentship was at first $600 a year, and each fellowship which would be given after, say after two years' tenure of a studentship was about $1,000 to begin with. Of course we have altered the conditions the amounts involved since. Twenty-five studentships and fellowships were established; but there were so few who, during wartime, applied for them that we only gave nine in 1917. Of those three resigned—I am speaking now from memory—to go across the seas. That leaves six out of twenty-five. Last year, when the Military Service Act began to operate, there were fewer qualified men available and we only had, I think, four before October last year, of whom only two completed their course. Since the armistice was declared we have got five or six more. We did not intend to confine the numbers to twenty-five, because we have to give assistance of this character for a number of years and for a large number of students. We intend to raise the number of studentships and fellowships to 100, as the students come forward. But there has been four years of non-production of scientifically trained graduates, and there will be another four years before the supply comes up to the normal number produced before the war. In other words, there will be an interregnum of nearly ten years in the training of scientific men in this country. The need of such is very great. Therefore, it was important for us, it was vital, to come to the rescue by establishing those studentships and fellowships.

Mr. STEVENS: What are the qualifications?

Dr. MACALLUM: For a studentship the applicant must be a graduate in one of the scientific departments listed. I have here the regulations governing this. It does not matter whether he is an honour graduate or not, so long as he knows enough science to begin research for himself, or to show that he has a research spirit. There are some distinguished men who have had so poor a class standing—I am speaking of the past now—that they might have been shut out from research if a high-class standing were exacted of them before being allowed to pursue it. We have to exercise discretion in awarding studentships and fellowships. A man must show that he has sufficient scientific knowledge, and that he has the research capacity. These qualities are not universally distributed. There are few men qualified for a scientific research career. Capacity for research is an unusual mental qualification in itself. There must be a consuming desire to achieve something in the way of breaking into new ground, and we have to be sure that the men selected have that qualification. When a studentship is awarded, the researcher works for a year and reports results to us. If he does well his studentship is continued another year. If in his second year he does better—and he is bound to do still better if he is worth anything—he then gets a fellowship. In 1917 we gave three fellowships to students who held them in Canadian universities.

Mr. ROSS: Do you mean by that that you pay his fees?

Dr. MACALLUM: No, he looks after that himself.

Mr. ROSS: What does it mean?

Dr. MACALLUM: It means that the amount of a studentship will enable him to pay his way while carrying on his researches in the university for a year. That amounted in 1917-1918 to $600, but as it was claimed that it was not enough to pay his expenses it was last year raised to $750.

Mr. ROSS: That enables him to attend the post-graduate work at the university?

Dr. MACALLUM: Yes, the amount is not large but we must not raise the amount so high as to be a bribe to bring in men who have not the right spirit. There must be in the holder of each studentship and fellowship the real research spirit.

Mr. ROSS: If he does well you give him a scholarship?

Dr. MACALLUM: A studentship the first and second years and a fellowship the third year. A fellowship is a greater distinction than a studentship. It shows that

the student has "made good", that he has done work of great importance along a particular line.

Mr. McGIBBON: It is an academic honour.

Dr. MACALLUM: I am now placing before you one of the greatest difficulties. We hope that with these studentships and fellowships, there will be produced a class of trained scientific research men who will go into the industries, or who will work for the guilds for research that I shall refer to later on. There will be, we hope, a constant flow of men of this character through the universities to recruit the profession of research. Unfortunately our universities are not equipped and staffed to accommodate fifty of such students at a time, now or later one hundred. Where is the surplus to be accommodated? They should not be sent to American universities and provision must be made for them in Canada—this is a situation which is giving the Research Council cause for anxiety. With the view of increasing the facilities offered in Canadian universities it has interviewed the authorities of McGill and Toronto and it proposes to interview those of Queen's, Dalhousie and so on, but so far the prospect is not encouraging. The Research Council found that in order to develop the resources of the country we would have to make grants in aid of investigation.

Mr. SHEARD: To the university or the student?

Dr. MACALLUM: To the individuals. Many scientific projects are incapable of realization or development unless they are assisted. Take one instance, the question of the use of straw for producing gas on the farms in the west. That involves an expenditure of money that no professor or investigator can meet out of his own pocket. The grant made by us in this case, however, has not been used. The material, the steel retorts and other equipment cannot yet be obtained. Then we made a grant for signalling through fog. Navigation on the Gulf of St. Lawrence is handicapped for the greater part of the season by fog. There is no proper method of signalling in foggy weather to prevent such disasters as occurred to the Empress of Ireland some years ago. Professor King, of the department of physics in McGill University, undertook this work. The appropriation needed was large. He applied unsuccessfully to the Naval Department for a grant, but finally obtained it from the Research Council. He is now working on this problem. Its solution will be a tremendous boom to navigators in the St. Lawrence. Later a grant was made for research on the utilization of low grade iron ore. Our country abounds in ore of this description, and the question is, how should it be utilized to compete with imported high grade iron ore, which constitutes 96 per cent of all smelted in Canada. A grant was also made in 1918 to Professor Thompson, of the university of Saskatchewan, to assist him in developing a variety of wheat that would be rust-resisting and ripen earlier than the Marquis, and would have good milling and baking qualities. A second grant, that is one for 1919, has been given him to continue this research. He has succeeded so far in breeding certain varieties, one of which will ripen two weeks earlier than the Marquis, and others which are more or less completely rust-resisting. In the West rust sometimes proves a very serious cause of loss. In one year the damage amounted to $19,000,000. Professor Thompson has brought his experiments to a point where he is now endeavouring to produce a hybrid that will ripen early and have the rust-resisting qualities of the parent wheat, and will also possess good milling and baking properties. I need not dwell upon what the results will be if he finally succeeds. Another problem taken up is the utilization of the tar sands in the West. There are 1,500 square miles of tar sands in northern Alberta, near Fort McMurray, in a stratum from four to ten feet thick, and the tar in the deposit ranges in concentration in amount from 10 up to 70 and 80 per cent. The tar sand, as such, was used to pave a street in Edmonton. That pavement has been in use five or six years, and it is found to be exceedingly good. The quantity of sand mixed with the tar is a handicap for if transported long distances the

sand will be a serious factor in the freight charges. A grant was made to determine a cheap method of separating the tar from the sand on a large scale. Unfortunately the project has so far not been undertaken because of the impossibility of finding scientific and specially qualified engineering experts to carry it on. A large grant was made to determine whether the tar in the bog of coke and gas plants could be precipitated electrically. At Riverside, California, a cement manufacturing plant, some year ago, sent into the air clouds of dust which settled on the orange orchards and vineyards and injured them. The company concerned was compelled under a mandamus to remedy this, and to meet the situation it put in the plant an electrical installation for the purpose of precipitating the dust before it got out of the chimney. It was successful and with an unexpected result quantities of potash were found in the precipitated dust, so large that potash became the chief product and cement became, as it were, a by-product of the plant. That suggested the investigation on tar fog. They pour out of many gas plants large quantities of tar, and it was thought that it might be possible to use electricity to precipitate it. The method is effective, but the question is whether the process is industrially feasible. It was proposed to utilize this process in a couple of plants in Canada but no action has as yet been taken.

Mr. THOMPSON: Did you say for the tar fog or the potash?

Dr. MACALLUM: For the tar fog in the coke plant at Sydney, and for the potash in cement-making plants.

The Research Council gave attention to the enormous supplies of lignite in the West. The two western provinces of Manitoba and Saskatchewan imported in 1915, 530,000 tons of anthracite from Pennsylvania at a cost ranging, according to locality, from $12 to $18 and $20 a ton. Now, there are in Saskatchewan 57,000,000,000 long tons of lignite. These lignites contain about 30 per cent of moisture. So long as the water is in them they stand handling and can be utilized; but in two weeks after mining they lose nearly all the water and slack and leave nothing but dust. Attempts were made in Saskatchewan in the last ten years by Mr. Darling, under the auspices of the Saskatchewan Government, to carbonize this slack material and convert it into a domestic fuel. Trials also, were made by Professor Babcock on the lignites of North Dakota, and data were available from experiments made by the Fuels Division of the Mines Branch in Ottawa. All these experiments seemed to indicate the feasibility of carbonizing these lignites and converting them into high grade fuel, and at the same time saving the pitch or tar and other valuable by-products. The finished briquettes were as effective in producing heat as anthracite. They burned slowly, gave out a strong heat, stood up in the furnace, and produced very little soot. The Research Council held that with 57,000,000,000 tons of these lignites in Saskatchewan and with about 600,000,000,000 tons of higher grade lignites in Alberta, it was incumbent on us to investigate their availability for domestic use and the possibility of replacing the anthracite imported. Remember that the anthracite imported into these parts of the country costs from $4,000,000 to $5,000,000 annually. The furnaces of the West are fitted only for anthracite, and even in the large government buildings in Winnipeg, anthracite was used simply because, even in the form of slack it was better than lignites. When I was in Winnipeg in 1917 the Hon. Premier Norris told me that the Government had bought 13,000 tons of anthracite slack for the public buildings, costing $10.75 a ton; and yet they could have bought lignite at about $5 or $6 a ton. You see the handicap there is on these lignites as fuel. We estimated that they could be carbonized and briquetted at about seven dollars a ton.

Mr. STEVENS: Including mining?

Dr. MACALLUM: Yes, including everything. It is possible that we were wrong in our estimate of some factors. We have to accept the data given to us by others and therefore we were more or less in reserve on this point.

Mr. McGIBBON: A ton of briquettes would be equivalent to a ton of anthracite?

Dr. MACALLUM: Yes, about 12,000 British thermal units per pound. In the estimate of the cost the value of the tar, gas and ammonia produced in the carbonizing was not considered.

Mr. THOMPSON: It did not include the by-products?

Dr. MACALLUM: No. These were not included. No use perhaps might be found for them. The West is very extravagant. The gas company of Winnipeg turns all the ammonia that is produced in its plant into the Red river. The amount of ammonia so thrown away annually is equivalent to more than 1,500 tons of ammonium sulphate. When the people of the West begin to conserve its resources, and know how to preserve the productive richness of its soil, it will use some of those by-products. It must do so some day.

Mr. McCURDY: To what extent does your Committee carry on instruction or propaganda?

Dr. MACALLUM: The members of the Council have given a large number of addresses. They have addressed Canadian clubs, rotary clubs, technical societies, etc., I have delivered more than fifty addresses myself.

Mr. STEVENS: I have no doubt there are a great many cases like the Winnipeg Gas Works. Did you advise them?

Dr. MACALLUM: The matter was carefully considered. There was during the last three years a great demand for ammonium sulphate in the West Indies. It is needed there for the tobacco fields. We made a census of the ammonium sulphate production of the Dominion. We thought of asking the Food Control Board to compel the Winnipeg Gas Works to put in a recovery plant, but as the West is not educated up to the point of using fertilizers on a large scale and as the cost of installing a recovery plant and the charges of transportation of the product to the proper market would be high we took no action. I hold that every one of these gas plants throughout the country, that might produce some hundreds of tons of ammonium sulphate a year, should put in a recovery plant. The gas works produce up to 28 hundred tons and from that down. In Sydney the Dominion Iron and Steel Works produce 1,600 tons.

An Hon. MEMBER: That does not go to waste.

Dr. MACALLUM: No, that goes to the West Indies.

Mr. STEVENS: Could they not utilize this commercially?

Dr. MACALLUM: The installation of the recovery plant is the essential; there is no market in this country and the transportation cost is too large.

Mr. STEVENS: It is not commercially possible.

Dr. MACALLUM: That is the trouble, Westerners do not recognize the value of the product.

Mr. THOMPSON (Yukon): You hope to make the recovery of sulphate of ammonia commercially possible?

Dr. MACALLUM: Yes.

Mr. ELKIN: Apropos of that question, you want to go a little bit further and you will be interested in learning that the Mellon Institute is making enormous strides in the last 18 months in connection with the extraction of toluol and benzol from tar and from coal oil, and they are going to revolutionize commercially the extraction of these two chemicals. It is going to make, for instance, our shale properties in New Brunswick, and western sand tars very valuable from a commercial standpoint. Now by the cracking process used by the Standard Oil Company they extract from 25 to 40 per cent according to the qualities they use. The is a commer-

cial plant which would extract from 75 to 80 per cent, and they have raised the benzol from 1·85 to 8·90 so that all these things eventually, if it is commercially possible, may be of great importance.

Dr. MACALLUM: Remember this, gentlemen, that the West contains large quantities of lignite and bituminous coal. Now, Nova Scotia and New Brunswick have only one-fiftieth of the Canadian supply. The coal is largely of this bituminous and lignite variety in which there are immense quantities of sulphate of ammonia. The question is whether, in the future, such coal will be burnt as fuel in the raw state in furnaces or whether it is first of all carbonized. This is a question which opens up immense possibilities for the West.

The Council recommended a grant of $100,000 should be made to provide for the establishment of a plant for carrying out experiments on the carbonizing and the briquetting of the lignites of Saskatchewan. The Government was inert about the matter because they had not, perhaps, the same interest in it at the time as the Council had. The Governments of Saskatchewan and Alberta were asked subsequently to assume part of the cost. After some delay the Reconstruction and Development Committee of the Cabinet considered our proposal and the Government in co-operation with the Governments of Manitoba and Saskatchewan, provided $100,000, $200,000 from these two provinces and $200,000 from the Dominion Government Treasury, to erect a plant and to carry on experimental investigation to demonstrate the commercial feasibility of the carbonizing-briquetting process, there the connection of the Research Council with problem terminated. When the Government adopts our recommendation on any matter our work on it is done. We are merely advisory; we as a body do not carry on experimental work. The three Governments have constituted a Lignite Utilization Board consisting of three members, in which Mr. R. A. Ross represents the Dominion Government, Mr. Leamy that of Manitoba and Mr. Sheppard that of Saskatchewan. This Board is now preparing to begin the installation of a plant, not much later than the first of October next, to turn out 30,000 tons of these briquettes and to sell them to the public, keeping track of all the costs so as to determine what the commercial possibilities of the carbonizing-briquetting process are. If the process is shown to be successful financially there will be many plants of that kind in the West because a good substitute for hard coal is a necessity. There are 20,000 domestic furnaces in Winnipeg fitted for burning anthracite but not lignites, except under great inconveniences. In Regina, in Moosejaw, in Saskatoon, there are large numbers of such furnaces. The supply for domestic heating, of anthracite or a good substitute for it, in all these centres is consequently very necessary. The price of anthracite went as high as $22 a ton in some centres in 1917. This indicates the urgency of an experimental demonstration of the value of carbonizing-briquetting process.

Mr. MCCURDY: The statement was made early in your remarks that the United States were much in advance of Canada in the matter of scientific research. What has been the result of the experiments that you speak of in the States having corresponding objects to those you desire to attain, and dealing with the same problems? I believe it has been covered there pretty well.

Dr. MACALLUM: They have lignites there in some places; but they have ample supplies of high grade fuel like the bituminous coal of Ohio, and the anthracite of Pennsylvania. Except for Professor Babcock, no carbonization has been attempted, but briquetting of the slack of anthracite and bituminous coal is carried on extensively at some centre. At some points in Pennsylvania the slack cast into rivers in former years is being dredged out and briquetted. There is no question about the value of briquetting. That is resorted to in Germany, where millions of tons of briquettes are turned out annually from lignites. The product is suitable as fuel for domestic furnaces of a different type from that of Western Canada because the climate of

Germany is milder. The question which is of dominant interest to us is the commercial feasibility of first carbonizing and then briquetting low grade western lignite to make a substitute for hard coal.

There are a large number of other investigations to meet the expenses of which the Council gave grants. It might prove tedious to refer to all of these and can only be touched on. It concerned the utilization of the sugar of sulphite liquors from the pulp mills which turn out millions of tons of these liquors annually, of which 10 per cent is solids containing sugar. The character of this sugar and what variety of yeast organism could transform it into ethyl alcohol were the subjects investigated. This was found to be readily convertible into alcohol, a fact of importance, since a careful estimate shows that if all the sulphite liquors of our Canadian pulp and paper mills were utilized for making alcohol for industrial purposes more would be thus produced than is now used in Canada. Using such liquors for this purpose would do away with the necessity of using grain for making alcohol. Industrial alcohol is required for the manufacture of paints, varnishes, rubber, textiles, the making of artificial leather, and so on. There is a bill to this end now before the House to which there is some opposition, but I hope it will go through with the main features of it unaffected. Amongst the general questions considered by the Council was that of patents to Government employees. In research laboratories the worker may discover something that is worth patenting. The question is whether he should be allowed to take out a patent for it. In Australia provision is made for bonuses, a certain amount accruing to the discoverer of the patentable idea. In our governmental departments here, for instance the forest products laboratory, investigators are not, or, at least, were not, allowed to take out patents. The consequence is that employees resigned and went to the States, where they secured patents and carried on their work. This condition and low salaries have practically depleted the staff of the Forest Products Laboratory in Montreal. As a result of the consideration given to the question a bill has been prepared dealing with the matter and enabling the Government to retain one-half interest in each patent for Canada and give the other half to the patentee, who is thereby allowed to patent the process abroad in his own name. The main effort of the Council was to introduce science and scientific research into the Canadian industries. Out of 3,000 firms there are perhaps about 1,000 which could and ought in some way to benefit by the application of scientific research to their problems, but their means are small, they cannot afford a large outlay. A firm that can only give about $4,000 or $5,000 a year cannot hope to reap much from research, unless it happens to be confined to one or two special points, and then one man may succeed in developing something which may increase the amount or the value of the output. Take the tanneries for example: There are between forty and fifty firms in this country whose methods would benefit greatly by research; but their annual sales are not sufficient to enable them to meet the expenses involved. There are indeed a few firms in this country which can afford to undertake research on a large scale. There is for example the Imperial Oil Company, Ltd.; I was informed by the late Mr. W. J. Hanna that the Imperial Oil Company spent $240,000 annually for research and exploration in Canada. The Consolidated Rubber Company, of Montreal, spend between $40,000 and $50,000 a year. The Davies Company in Toronto spend a considerable amount, I could not say how much. But let me repeat the amounts which many firms in Canada can spend for this purpose are very small and they consequently cannot hope to get valuable results. In the United States there are over 50 firms that spend anywhere from $25,000 a year to $2,000,000. The Eastman Kodak Company spends several hundred thousand; the General Electric of Schenectady, I think spend more than $250,000. The Western Electric spent last year $2,200,000. The Dupont Company spent about the same amount. The National Electric Light Association spent over $200,000 on research. These firms are liberal in their expenditures in the

encouragement of research as they know it is wholly in their own interests. Wealthy firms can afford to do this, and some firms become monopolies in consequence. The Eastman Kodak Company, for example, has many, perhaps hundreds of patents in its pigeon-holes. It does not use them except when competition threatens and then it utilizes one or more of its patents and the competitor is crippled. The consequence is that the smaller firms are crushed out, or if they are not extinguished altogether they become merged in the larger concerns. They have to sell out. Now, this is very undesirable, and one does not want to concentrate all manufacturing in a particular line in one large firm. But if a firm has resources for research and can discover useful processes, it has an immense advantage over smaller competitors. In this country there are very few or no such large firms. We have sixty odd pulp and paper concerns; we have forty to fifty firms engaged in the tanning industry. We have something over a dozen rubber firms. There are similarly situated a large number of firms in other lines of industry. The question that arose was how could research be made available to these firms, and after consideration of everything involved it decided to encourage the firms in each particular kind of industry to unite, to form what they called trade associations for research which would pool all their funds for research. If funds so raised are not sufficient in any case, the Research Council places at the disposal of the trade association a grant not to exceed pound for pound of the pooled funds. There are now thirty-four of these trade associations, that is there are that many industries which co-operate for research. They provide their own research laboratories. They employ their own staff and the funds at their disposal are very large; sometimes the amount would be over $50,000 a year. That suffices to employ a large research staff. The Research Council of Canada took a leaf out of the book of the British Research Council. It advocates the formation of guilds for research of the firms in the various lines of industry which would engage to pool their funds or reserves for the purpose of engaging research men to investigate their problems. The Research Council could not make, for reasons which you will gather yourselves, substantial grants like those which the British Research Council is prepared to give to the trade associations for research. But we hoped to give these guilds for research advantages which would equal that which the British Research Council provides, for the trade associations for research. These advantages would be free accommodation, light and heat in a National Research Institute. There is in Canada no National Research Institute like the National Physical Laboratory of Great Britain, the Physikalische-Technische-Reichs Anstalt and the Chemische Anstalt of Germany, the Bureau of Standards at Washington. The Research Council recommends the establishment of a National Research Institute for Canada which will parallel in a modest way for the next few years the Bureau Standards at Washington and that in the building which is to house this institute there be free accommodation for the staffs of the various guilds for research. This with supervision that the staff of such an institute would exercise over the work carried on by the staffs of the guilds housed in the institute, would greatly promote the success of the researches carried on by such guilds. There is great urgency in the need of such an institute in Canada. We must give our industries such advantages as the American industries possess through the activities of the great scientific bureaus, the Bureau of Standards, the Bureau of Chemistry and the Bureau of Mines, which the National Government of the United States maintain. The expenditure of those bureaus is very great. The Bureau of Mines Department runs up to over half a million dollars a year, the Bureau of Chemistry to about $800,000, while the Bureau of Standards last year spent two million dollars.

The CHAIRMAN: And a million and a half dollars for new buildings.

Dr. MACALLUM: Yes. The Bureau of Standards has a laboratory for testing and standardizing materials used in industry and in Government work. It was primarily for standardization of the materials used in the construction of public works, but

lately it has gone into investigations of standards in the products of the industries. It will standardize all sorts of manufactured products, textiles, rubber, leather, etc. They are even willing to standardize the products of Canadian manufacturers. They give a certificate with the standard. Any Canadian manufacturer can send his product to Washington and have it standardized; and when standardized, he must, thereafter, put out a product up to that standard, so that it is a check upon him, an incentive to him to maintain the value of his product. You will find in your copies of "Science and Industry," page 32, a resumé of the work which that bureau does.

The CHAIRMAN: I notice that their report last year covered two hundred pages.

Dr. MACALLUM: This was written four years ago, since which time the Bureau has developed enormously.

Mr. MCCURDY: I see that this is published in London.

The CHAIRMAN: It is published for the British Research Council, which is similar in its constitution and functions to the Canadian Council.

Dr. MACALLUM: We received the copies from it. There is no institute in this country which could house the staffs of our guilds for research. In the United States they have the Mellon Institute, for example, and there are other similar organizations of much less importance.

The CHAIRMAN: That is at Pittsburg?

Dr. MACALLUM: Yes, it is an organization provided by Mellon Brothers who gave a grant of $500,000 for the construction of the buildings. The staff is maintained there and an industrial firm can put one or more research workers on its problems in the rooms of that institute. A small annual charge is made for the privilege. These research workers carry on their observations under the supervision of the staff of the institute. I may say that the Bureau of Standards at Washington does work of this character for the industries. If it is of special benefit only to the firm that requires it, that firm is charged with the expense. If it is of public benefit, it is free to the firm, but the benefits of it are for the public alone.

Mr. NICKLE: Who maintains the Mellon Institute now, the Government?

Dr. MACALLUM: No, it is associated with the University of Pittsburg.

The CHAIRMAN: The Mellon Brothers are very wealthy bankers.

Dr. MACALLUM: Yes, and they provide everything. They take a pride in the results.

Mr. MCCURDY: The revenue is derived from different sources, a part from the Mellon Brothers and a part from those who benefit from the experiments.

Dr. MACALLUM: Yes.

The CHAIRMAN: I think the Mellons carry the heavy part of the load.

Mr. MCGIBBON: In what way are benefits given to the public?

Dr. MACALLUM: The firms which engage staffs working in the Mellon Institute have the rights of any discovery for a few years, after which any firm in the lines of industry concerned may use the new processes without royalties or payments for them.

Mr. MCGIBBON: I was thinking of the ultimate cost to the public. Would it be a case of adding more profit to certain firms.

Dr. MACALLUM: That will depend on the circumstances in each case. The Bureau of Standards acts on the assumption that if the benefit of a particular research can only be enjoyed by an individual firm, it will carry the research on at that firm's expense; but, if the results of a research are going to benefit the whole industry, in which there are probably several hundred firms, it will carry on the research for nothing. Then all the firms in the industry can have the benefit of the results.

Mr. NICKLE: Does the same principle underlie the administration of the Mellon Institute?

Dr. MACALLUM: Yes, to a certain extent. There are conditions arranged for each individual case. It depends altogether on the largeness of the point of view of the manufacturer. But there is a time limit to the use of the benefit in any case. I am speaking from memory, but I think it is about two or three years. The Mellon Brothers take a pride in what these firms do. There was one firm that spent large sums annually on their yeast production. It felt that the costs were too great, and the product not satisfactory, and it installed a researcher in the Institute, who succeeded in developing new processes of cultivation giving a more satisfactory product, with the result that the firm saved over half a million dollars, I think, in two or three years, through this alone. It gave the worker, besides a salary for one year, a bonus of $10,000 for each of the three following years.

Mr. STEVENS: Did they reduce the price of bread?

The CHAIRMAN: They said they improved the quality of the article very much.

Mr. NICKLE: Is not that the case where the country at large benefits?

Dr. MACALLUM: The rights involved now belong to the public, I understand.

The CHAIRMAN: Then you are going to develop the idea of the laboratory system in certain institutions?

Dr. MACALLUM: Yes, of course we cannot multiply institutes in this country because our means are limited.

Mr. MCCURDY: Is it part of the functions of your body to investigate existing waste?

Dr. MACALLUM: Yes.

Mr. MCCURDY: For instance I am told that in the Department of Agriculture experiments are constantly being undertaken in the hundreds, duplicate investigations, in the different experimental farms throughout the country and it is contended by some that the waste in this respect is very far in excess of the benefits derived therefrom.

Dr. MACALLUM: It is the case all over the world; in the west the three provinces are triplicating the work.

Mr. MCCURDY: But I mean in the Dominion Department of Agriculture which maintains experimental farms carrying on exactly similar experiments, superfluous experiments, as regards cost and result.

Dr. MACALLUM: It may be true. //

Mr. STEVENS: You have such a diversity of climate conditions that what would be suitable in the prairies would be absolutely useless for us in British Columbia for instance, and that applies particularly to potatoes, vegetables and other crops.

Dr. MACALLUM: There is waste and we propose to investigate that question and make a report thereon; but we are up to the crown of our heads already in the work we have on hand, and it is hardly possible for us to extend our activities indefinitely.

Mr. MCCURDY: Some years ago there was a committee appointed, called the Economic and Development Committee, which investigated these questions. I wonder if we could have access to the finding of that committee. I would like to have a résumé of their findings prepared in brief form.

Dr. MACALLUM: To meet the demands of industrial development in the scientific way in Canada the Research Council recommends the foundation of a National Research Institute at or near Ottawa, which location of course has been suggested by conditions that everyone will recognize as determining the choice. This institute should have the functions of a Bureau of Standards for Canada, and also those of a

Mellon Institute. The constitution of a bureau of standards would give a supervising and directing force for the investigations that would be carried on in the Mellon Institute side of the organization. Research would be carried on, of course, both in the interest of the public and private enterprises. Industrial research carried on in such an institute, would be under the supervision of the highly technical staff, a staff selected specially because of their special capabilities for industrial and scientific research. The different organizations, the staffs of the different guilds would work side by side, and this would determine, to a certain extent, what would be the character of the staff on the bureau side of the institute. Nearly all our industries depend to a large degree upon chemistry, for example leather, textiles, clay products and rubber require a highly technical staff to meet the special needs and the conditions under which investigations have to be carried on. Now in investigating the raw material of the industries which I have named the application of colloidal chemistry is required but there are very few colloidal chemists available. Colloidal chemistry is all important from the industrial point of view. There is, however, in Canada only one authority on colloide but he is a physicist, not a chemist, and he deals with it from the physicists' point of view. There is in our Canadian universities colloidal chemistry, but investigations on textiles, leathers, rubber, etc., require the supervision of experts in colloidal chemistry who should be included in the staff of the proposed National Research Institute. If this institute were founded, it would be a centre not only for the determination of the character of the natural resources of the country, but also for industrial research. It would not preclude industrial research elsewhere. A single firm, or a group of firms if they desired to do so, could place their research work elsewhere. But you must systematize your organization so that, if these associations for research are formed, they will look naturally to some one place where they can get the most for their outlay, and this National Research Institute would be such an organization. For this purpose it should be staffed with experts along particular lines, including colloidal chemistry, which the universities have not the means to employ. To provide for the foundation of a National Research Institute, the Research Council recommended the construction of a building 200 feet by 60 feet by 74 feet, on a 50-acre site, that is, large enough to accommodate additional buildings in the future. There would be about sixty to sixty-four rooms in the building, of about 25 by 25 feet, excluding hallways, washrooms and accommodation of that kind. Such a building would be sufficient for the first ten years or so. That would accommodate the staffs of all the guilds which would be formed. It would have sufficient accommodation for the staff of the Bureau of Standards side of the institute. The amount needed for the construction of such a building would be $500,000; $100,000 for equipment, desks, plumbing and the like, and $100,000 for salaries for the first year of operation. The Council believes that the establishment of such an organization would lead to a complete revolution in scientific work in Canada. It would stimulate the universities to produce highly qualified researchers. The universities must produce such. That is the place where research men must be trained, not in this National Institute or in an industrial laboratory. Such research men can be properly trained only by carrying on research, for a time, in fundamental science, or, as it is more often called pure science. He can then turn readily to industrial research. A training in industrial research alone gives only limited powers and the researcher so trained is ineffective except on very special points. Industrial research in only the effort to find a process that will last for a few months, or a few years, or to make a process cheaper. It may be replaced or changed two or three years later and, therefore, it is ephemeral, so to speak. As a researcher cannot be effectively trained in industrial research alone, the universities therefore must provide for the training of such in fundamental science. If this National Research Institute were founded, universities would be called upon to produce these men. Of course they could not produce many at present, but with this institute in being and in operation, they would

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begin to produce them and we would tide over the next five to ten years with such scientific men as could be found.

Mr. NICKLE: Can you distinguish between pure science and industrial science? Is there a line of cleavage between pure science and industrial science?

Dr. MACALLUM: There is the distinction I made a little while ago.

Mr. NICKLE: You spoke of Faraday and his work which was a great advantage industrially. Faraday simply began a research in pure science, which ultimately was turned to the advantage of industrial science.

Dr. MACALLUM: All industrial science is based on pure science.

Mr. NICKLE: You cannot make a line of cleavage, can you?

Dr. MACALLUM: If you go over the history of industrial chemistry, you will find many processes are advocated, but these are all based on the fundamental facts of pure science. Fundamental science has to grow before you can avail yourself of all its resources for industry.

Mr. NICKLE: Industrial science builds on pure science and takes advantage of it.

Dr. MACALLUM: Yes, and many of its facts are, from the nature of things, only of ephemeral value.

Mr. NICKLE: It is the application of scientific principles to commercial problems.

Dr. MACALLUM: Yes.

The CHAIRMAN: Pure science discovers and industrial science utilizes. That is putting it shortly.

Dr. MACALLUM: That completes what I have to say.

Mr. THOMPSON (Yukon): I am not clear on what you might call the matriculation requirements of the Central Research Laboratory, which is the central idea of your scheme. It has to be recruited from the universities. What connection is there between university laboratories and the guilds and the research?

Dr. MACALLUM: The Bureau of Standards side of the Research Institute will take qualified men wherever it can get them to constitute the staff of the institution. That staff must be recruited from the graduates of the University in science, the highly specialized researchers. The guilds, availing themselves of the opportunities of the Mellon Institute side of the institute, will engage the researchers of that type also for their staffs, and these will be selected under the supervision of the staff of the Bureau of Standards side of the Institute.

Mr. SHEARD: The bureau would be intended to direct the line of investigation, and the Mellon would be the suggestion of capable minds to apply the suggestions.

Mr. THOMPSON (Yukon): There is in this country a strong current of opposition to this Central Bureau of Standards by our graduates.

Dr. MACALLUM: No.

Mr. THOMPSON: Queen's University is opposed to it.

Dr. MACALLUM: Quite so. I understand they are not opposed to a Bureau of Standards but to the Mellon Institute attachment.

Mr. THOMPSON: Some people have spoken to me about it, and while I may be wrong in saying there is a general feeling against it, I know there is some opposition to it.

Dr. MACALLUM: We have not got unanimity. We never could get unanimity in the whole country on that question.

Mr. THOMPSON: Unanimity is a rare flower. Where do the guilds recruit their men?

Dr. MACALLUM: They would get highly specialized men wherever they could be

found. If they can be produced by the Canadian Universities, well and good. They may have to get them from the United States.

Mr. NICKLE: As to the Mellon side, who is going to pay those men? The Government?

Dr. MACALLUM: The guilds.

Mr. ELKIN: The guild is a group of individuals interested in some industry.

Dr. MACALLUM: It will pay the salaries of its own staff. The only advantage it will get will be free accommodation, light and heat.

Mr. ELKIN: These men training on the fundamental side, as they take their second, third or fourth years in the colleges will begin to specialize themselves; for instance one man's science will be motor mechanics and so on.

Dr. MACALLUM: Oh yes, for instance, it may be in economic biology; it may be in physics; it may be in metallurgy, mineralogy or chemistry.

Mr. NICKLE: What is going to happen to the university professorate once they all gravitate to the research schools?

Dr. MACALLUM: The universities will get their men. University Professorships because of the security of their tenure and the prestige attached to them will always be regarded by a very great many researchers as preferable to industrial research positions. The universities ought to produce a large number of scientific research men so that the public would have the benefit of the services of such as are not required in the universities. They ought not to be scientific monasteries, retaining for life every scientific man who enters them. There ought to be a constant stream into them of scientific students and out of them as large a stream of fully trained research men.

Mr. THOMPSON: Will not this give the university graduate a new field for action?

Dr. MACALLUM: Certainly. In conclusion I may say that I have dealt with our scheme as a whole only. There is one question untouched on which is a pretty lively one, but the discussion on it can wait for another opportunity. It is a question of the survey of our natural resources.

Mr. ELKIN: I would suggest that we proceed to get the views of those whose names have been mentioned, and then we will be in a position to call upon Dr. Macallum again.

The Committee adjourned.

Tuesday, May 20, 1919.

The Committee met at 10.30 a.m.

The following communications were received and ordered to be placed on the record:—

TORONTO BOARD OF TRADE,
TORONTO, April 24, 1919.

Sir THOS. WHITE,
Acting Premier,
Ottawa.

Toronto Board of Trade strongly urges upon the Government the necessity of establishing a Research Institute.

F. G. Morley,
Secretary.

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HAMILTON BOARD OF TRADE.

Resolution passed by the Council of the Hamilton Board of Trade, May 1, 1919.

Whereas the people of Canada are confronted with the problem of carrying the very heavy National Debt incurred by their participation in the Great War for humanity.

And whereas this burden can be borne only through the greatest thrift and industry on the part of the nation, through the conservation and development of our human and natural resources, so that we may be able to share in the world's markets against the strong competition that we shall have to meet.

And whereas good results have already been achieved by the Industrial Research Committee.

Be it therefore resolved that this Board strongly supports the establishment of a National Research Institute and urges that legislation in this connection be passed at this session.

(Sgd,) T. L. Brown,
Secretary.

Resolution passed by the Canadian Fisheries Association in Executive Session at Ottawa, May 13.

In the opinion of the Canadian Fisheries Association the establishment of a Central Bureau of Research is not advisable but the work now being done by the Biological Departments of our universities should be strengthened by a Federal Subsidy distributed through the provinces in the same way that the Federal Subsidy was given to the Agricultural Colleges. The establishment of a Bureau of Standards is advisable but should be put under the jurisdiction of a department of the Government rather than under the Advisory Council of Scientific and Industrial Research.

LONDON CHAMBER OF COMMERCE,
London, Canada.
Tecumseh Building, May 17, 1919.

Dr. A. B. MACALLUM,
Administrative Chairman Honorary Advisory Council Scientific Research,
Ottawa, Ont.

DEAR SIR,—I am instructed to advise you that our Directors endorsed the resolution of the Hamilton Board of Trade declaring their hearty support of the establishment by the Government of Canada of a National Research Institute which would carry on and direct research into such industrial, agricultural, commercial and medical problems which will best promote the conservation and development of Canada's human and natural resources.

Yours very truly,

(Sgd.) Gordon Philip,
Managing Secretary.

RESOLUTION OF THE PORT ARTHUR BOARD OF TRADE.

PORT ARTHUR, ONT., December 16, 1918.

Whereas it is stated in the Toronto newspapers of December the 4th that "The Reconstruction Committee of the Cabinet has decided to accept the recommendation of the Honorary Advisory Council for Scientific and Industrial Research for the establishment of a Central Research Laboratory. It is proposed to appropriate half

a million dollars for the purpose. Part of this will be expended in a central bureau at Ottawa, while there will be smaller research laboratories throughout the country for the sake of aiding industry."

And whereas it is proposed that the new Canadian Bureau be modelled partially on the Washington Bureau of Standards which concerns itself with heat, electricity, optics, chemistry, metallurgy, ceramics; and structural engineering and partially on the Mellon Institute at Pittsburg.

And whereas in the report of the Honorary Advisory Committee the following appears: Whether local branches of this Institute should be formed which the Research Council, though it has considered this object, is not prepared to offer a recommendation."

And whereas this Board of Trade has absolute faith in the resources of this district in metallic and non-metallic ores and concerning which we have frequently gone on record as calling on the various governments for assistance in research and development.

And whereas it has been frequently stated that the backbone of the various transcontinental railways is broken by the lack of a supply of freight in the centre of their system between Manitoba and the older parts of Ontario, which we believe could be largely overcome by a policy of research and development.

Therefore this Board of Trade do hereby resolve;

That it is in hearty sympathy with the proposed establishment of a Central Research Laboratory and smaller research laboratories throughout the country and to point the district of Thunder Bay as one of the fit and proper places in which one of the smaller laboratories should be placed;

That we are satisfied that the placing of such a laboratory at Port Arthur would do much to prove the great resources of the district, and start industries as a result thereof that would go a long way to overcome the present shortage of freights in the centre of the three great transcontinental systems.

And this Board of Trade is also in favour of strong local branches of this institute being formed and is prepared to assist any local branch located in this district and offer it the use of our mineral exhibit and any and all statistics in our possession. That copies of this resolution be sent to the members of the Reconstruction Committee, the Honorary Advisory Committee and F. H. Keefer, Esq., M.P.

MEMORANDUM TO THE GOVERNMENT OF THE DOMINION OF CANADA FROM THE ROYAL CANADIAN INSTITUTE.

The Royal Canadian Institute in meeting assembled on November 23, on motion of Mr. Arthur Hewitt, seconded by Mr. R. Wight Eaton unanimously resolved "That the Counsel of the Institute be instructed to prepare a resolution impressing upon the Dominon Government the necessity of immediately providing funds to enable the Honorary Advisory Council for Scientific and Industrial Research to carry on its work on such a scale as will meet the urgent demands of this period of reconstruction."

In accordance with this instruction, we, the Council of the Royal Canadian Institute beg to present for your consideration the following memorandum:

(1) The enormous debt caused by the war must be paid largely by new taxes to be levied on people already overburdened. This burden can only be reduced and

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financial solvency maintained by the development of all our national resources, agricultural and industrial. Such development cannot be successfully accomplished without the application of science to the utilization of undeveloped resources and the recovery of valuable waste products.

(2) The development of industry depends entirely on our ability to meet the competition of other countries in both export and home markets. To this end, the cost of production must be lowered to the scale existing in such countries as Great Britain and United States as well as Japan where low cost is made possible by (1) the lower standard of wages (2) the application of scientific research to industrial problems on a scale compared with which the efforts of Canada have been insignificant. Research work of these countries centre in National Testing and Standardizing Institutions available alike to large and small industries and to science generally. The remarkable industrial development of Germany was a direct result of the establishment of the Reichsarstalt in 1884, and the National Physical Laboratory in Great Britain and the Bureau of Standards in the United States have—particularly in the last few years —done equally extensive work. As regards labour the establishment of a higher wage scale in this country makes doubly important any means of decreasing cost of production.

(3) With the exception of Canada, all the leading allied countries, in order to handle the afterwar conditions are now seeking to increase their trade to a tremendous extent and for this purpose all their scientific organizations for research are being greatly enlarged. Japan, which has hitherto depended upon its cheap labour is now spending $5,000,000 on a national laboratory. In urging the Dominion Government, therefore, to establish a National Research Institution we are only asking for what other countries have found indispensable.

(4) Furthermore, we should like to point out that instead of adding to the financial burden of the country by the establishment of this institution, its work will inevitably result in savings which will more than pay the capital and maintenance charges. It is necessary to cite only the United States' Bureau of Standards whose supervision of the contracts of the United States Government has saved millions of dollars annually.

(5) We are insistent in this matter so that Canada may take her place in the family of nations, may meet her obligations easily and may furnish employment to its industrial workers. // We believe that the economic salvation of this country depends on the scientific development of its resources, and for this reason urge that your Government give ample and adequate support to the recommendations of the Honorary Advisory Council for Scientific and Industrial Research. //

On behalf of, and by order of, the Council of the Royal Canadian Institute.

Hon. Secretary.

RESOLUTION *passed at the Annual General Meeting of the Canadian Manufacturers' Association, held at Montreal on the 12th and 13th of June, 1918.*

RESOLUTION ON SCIENTIFIC AND INDUSTRIAL RESEARCH.

Whereas in the principal industrial countries the application in industry of results obtained by scientific investigation is recognized as a most important factor in maintaining a high industrial rank and increasing national prosperity;

And whereas realizing that it is not purely an industrial problem, but for the ultimate public good, Governments of the principal industrial countries have set aside large appropriations for the assistance and encouragement of scientific research as applied in industry;

And whereas the immediate Government provision in Canada for the application of scientific discoveries in industry is at a minimum;

And whereas industries have guaranteed financial co-operation on a considerable scale for a period of years provided Government action is forthcoming;

Be it therefore resolved, that the Canadian Manufacturers' Association in Annual Meeting assembled, strongly urge the Dominion Government in prompt action,

(1) To provide for the appointment of manufacturers in representative industries in the Honorary Advisory Committee of Scientific and Industrial Research on a basis equal numerically to the academic representation now thereon;

(2) Under the supervision of the Honorary Advisory Committee in co-operation with the industries on terms to be agreed upon, to establish, equip and maintain a laboratory for conducting scientific industrial research and furnishing information relative to new processes, properties, inventions, improvements, and materials discovered therein as may seem capable of use by interested manufacturers;

(3) To provide funds to carry out this project or another similar plan suitable to Canadian industrial conditions, which plan shall have the same end in view.

MEMORANDUM *of joint recommendations drawn up at a meeting held in Ottawa on Friday, November 29, 1918, by representatives of the Trades and Labour Congress of Canada, the Joint Committee on Technical Organizations, and the Canadian Manufacturers' Association, for presenting to the Dominion Government.*

(1) *Bureau of Public Welfare:*

That the Government be requested to establish immediately a Bureau of Public Welfare to deal with such matters as health, sanitation, town planning, housing plans, accident prevention, and every other matter pertaining to the physical efficiency of the nation.

Owing to the present dearth of suitable homes for working men, this particular subject should receive the Bureau's first consideration. Much could be accomplished through the co-ordination of the many agencies, private, philanthropic, and governmental, dealing with these matters.

(2) *Survey of Imports:*

That a permanent representative bureau be established to take a survey of imports with a view to ascertaining what part of such imports could be avoided. Particular attention to be paid to the classification of the customs tariff.

The information thus gathered should be as accessible to interested parties as similar information is in any other countries.

(3) *Raw Materials:*

The good work already done by our Government in arranging to have more of our minerals refined in Canada, as in the case of nickel, should be continued as a general policy relating to all raw materials, so that such materials will leave the country in as advanced stage of manufacture as possible.

(4) *Scientific and Industrial Research:*

Having regard to the important part which research must necessarily play in Canada's industrial reconstruction, the appropriation for that purpose should be increased to not less than one million dollars annually. The Board handling that

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work should not be merely advisory as at present, but should be clothed with specific executive powers, which powers should preferably be exercised by a board of managers, upon which labour, manufacturers and engineers would all have representation.

(5) *Immigration:*

That the establishment of a central Empire authority on emigration be approved of for supplying information to parties intending to emigrate, as to conditions in the countries to which they desire to so emigrate, and that the established Immigration Department in Canada give serious consideration to the question of further restricting undesirable immigration.

(6) *Public Works:*

All necessary public works, Dominion, Provincial and Municipal should be carried forward as promptly and energetically as possible. As the chief consideration will be the matter of finances, we would suggest that the Government render all possible financial aid to works not coming strictly within its own scope.

(7) *Technical Education:*

The advancement of technical education is of such vital concern to the whole country that the burden should not be left entirely to the Municipalities and Provinces. The Dominion Government should co-operate by such means as are best calculated to assist the authorities and expand the facilities for this work. It is urged, whatever plan be adopted, that there be kept constantly in mind the necessity of working it out on lines that will bring technical education within easy reach of all classes.

(8) *Land Settlement:*

That a practical land settlement plan be worked out at once, and in connection with same the Publicity Department should start a campaign to interest our soldiers in the advantages of farming.

An interesting series of booklets should be supplied to our soldiers as soon as possible and prior to demobilization, particularly designed to show that community farm life can be made not only profitable but sociably attractive in the older as well as the newer Provinces.

Educational facilities for the thorough training of soldiers who desire to settle on land should be provided.

It is further recommended that the Federal and Provincial Government take such steps as are necessary to procure suitable land for such communities in proximity to already settled areas.

(9) *Employment Bureaus:*

The establishment of one chain of employment bureaus, operated by the Provinces in co-operation with the Federal Government, is heartily endorsed, and in this connection the absolute undersirability of dual and private employment offices is emphasized and the abolition of such recommended.

(10) *Demobilization:*

The time having arrived for demobilization the Militia and other Governmental Departments should co-operate the Government Employment Bureaus in order that the lapse of time between discharge and employment be as short as possible; due regard being given to priority on account of length of service, and to married men.

(11) *Water Power:*

That the Government should adopt a fixed policy and a comprehensive scheme for the utilization of our water powers already and to be developed. This applies particularly to those on international waterways and especially to those of the St. Lawrence river.

To give industry the proper freedom for expansion power must be kept always well in advance of demand.

(12) *Optimism Campaign:*

That the Publicity Department of the Government start at once an optimism campaign, and that in this the press of the country be requested to co-operate.

The country is drifting into a pessimistic state of mind as regards the immediate future which might easily bring about far-reaching depression unless it is quickly checked.

Respectfully submitted,

Signed:

Labour representatives, T. Moore, and others.

Joint Committee of Technical Organizations, Willis Maclachlan, and others.

Canadian Manufacturers Association, H. J. Daly, and others.

The CHAIRMAN: We have in addition to these, two letters from private individuals, one from Mr. Andrew T. Drummond, of Grimsby East, who sends a lengthy communication which the secretary will read.

Mr. STEVENS: Who is he?

Dr. MACALLUM: He is a prominent graduate of Queen's University.

Mr. THOMPSON: He represents himself, does he?

The CHAIRMAN: I think he speaks for himself. The other letter is from a Major Mattice, of Quebec, who has been Chief Inspector of Arms for the Canadian Government, and who speaks of a Bureau of Standards. He asks to be heard before the Committee.

Mr. MCGIBBON: Whom does he represent?

The CHAIRMAN: No one but himself.

Dr. A. B. MACALLUM: Mr. Chairman and Gentlemen, my remarks this morning will be very short, in order that Dr. Mackenzie and Dr. Ruttan may both be heard at length to-day and to-morrow. Dr. Mackenzie is president of Dalhousie University and was a physicist of distinction for his researches before he became president of that university. Dr. Ruttan is the head of the Department of Chemistry of McGill University and has been identified with industrial chemical research for years. His point of view, and that also of President Mackenzie, will be of great value to the committee. Experience, I think, Mr. Chairman, should count in determining the estimate that should be placed upon the views that are expressed, and I therefore ask that they be given every opportunity because they have taken part in the work which enabled the Council to arrive at the decision to recommend the establishment of a national research institute.

There is one point which I should make quite clear in the minds of the committee and that is the functions of the proposed National Research Institute. These are indicated in a statement, copies of which are for distribution among the members of the committee, to go around. You will recall that the institute is to have two functions, one for standards of all sorts, the other to provide opportunities for industrial research on the part of single firms or groups of firms which may be formed for the purpose of furthering their own industry by research into their various problems. I will read this:—

"The institute shall have charge of:—

(*a*) the investigation and determination of standards of length, volume, weight, mass, capacity, energy, and time, and of the fundamental properties of matter.

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(*b*) the standardization of the scientific and technical apparatus and instruments for Government service and for use in the industries of Canada and of the materials used in the construction of public works.

(*c*) the investigation and standardization of the materials which are or may be used in the industries, and of the products of the industries.

(*d*) researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries.

(*e*) researches undertaken to promote the utilization of the natural resources of Canada."

Now all that is on the Bureau of Standards' side. Then on the industrial side there is the following:—

"The Institute shall have charge, direction or supervision of the researches which may be undertaken or by or for single industrial firms under conditions to be determined in each case or by such organizations, to be known as Trade Guilds for Research, which may be formed in the various industries with the view of improving the processes of production or the products of these industries, as may desire to avail themselves of the facilities offered for this purpose by the Institute."

This is a condensed statement describing the functions of the Institute. Now there is a point in this connection which I think deserves emphasis. The industries of the country are going to be faced with serious competition from abroad in which no resource that science possesses will be ignored. The American industries are now adopting a progressive attitude towards research. There are, it is estimated, three thousand industrial laboratories in the United States and for these laboratories large sums are spent. I mentioned the other day in the representations I made to the Committee that there are over fifty large industrial firms in the United States which spend anywhere from $50,000 up to $2,000,000 a year. We have nothing to compare with that in this country. //

Hon. Mr. BELAND: All these establishments are provided for by the industrial firms or are they provided for by the Government?

Dr. MACALLUM: None by the Government, they are all private.

Mr. SHEARD: Would it not be a very serious thing to interfere with such an arrangement?

Dr. MACALLUM: We do not propose to do so, what I am indicating is the situation which is developing, because these large industrial organizations are following this research to such an extent that they will capture all the markets of the world.

Mr. SHEARD: I do not know how far this goes; I do not wish to criticize, I am simply asking for information. We have here in the first proposition the determination practically of the standards and that is at once a very radical act, and it is going to raise in my mind the question of metric system at once.

Hon. Mr. BELAND: As I understand it, this institute would have the power to determine that in Canada in future we will have the metric system and no other.

The CHAIRMAN: Perhaps if Professor Macallum will give us some indication of what the Bureaus of Standards in the United States are doing, it would be of advantage to the committee.

Mr. THOMPSON (Yukon): In reference to the United States do I understand they have a Bureau of Standards as well as the Mellon Institute—I am speaking now of the United States Government.

Dr. MACALLUM: They have a Bureau of Standards which carries out exactly this work.

Mr. THOMPSON: The two functions are clearly defined in the scheme we have before us now. Does the Bureau appointed in Washington function in that way?

Dr. MACALLUM: Yes, the same as indicated in clauses A to E.

Mr. THOMPSON: I understand that as far as the Bureau of Standards is concerned, but does it apply as far as the work of the institute is concerned.

Dr. MACALLUM: The Bureau does take up work for various firms and carries the investigations on; if the results are found to be of wider interest than concerns that individual firm the Bureau of Standards meets the expense of the research. If the results are only of benefit to that individual firm that firm pays all the expense. Sometimes however the Bureau independently carries on investigations on problems bearing on important industrial questions.

The Bureau does not ostensibly take on the functions of a Mellon Institute, but like the latter it helps to solve the problems of individual firms.

Mr. STEVENS: I presume that A, B and C are really the functions of the Bureau of Standards. Am I right in that?

Dr. MACALLUM: Yes.

Mr. STEVENS: Then will you tell me the connection with the United States Government? The Bureau of Standards is a department of the government, is it not?

Dr. MACALLUM: Yes.

Mr. STEVENS: But the Mellon Institute is not a government institution.

Dr. MACALLUM: It is private.

Mr. STEVENS: Another point; in regard to the question of research, which I am taking as distinct from the Bureau of Standards, does the United States Government give any assistance to the universities, and secondly, does the government institute do research work itself?

Dr. MACALLUM: The United States Government has not hitherto given any grants for research to the universities. The Bureau of Standards carries on research on a large scale and in its own laboratories. It gives isolated problems out here and there to universities, but these are very few in number, and they do not appreciably count in the sum of results at the end of the year. As I said, the United States Congress has not made any provision for research in the universities, but there is, or was, a bill before Congress known as the Smith-Howard Bill, introduced last November, providing federal aid to promote scientific and industrial research in the States, Territories, and the District of Columbia in connection with the higher educational institutions.

This bill has not been accepted. It has been very extensively and drastically criticized, and the National Research Council, which of course desires to bring to the aid of research all the adventitious forces possible suggested improvements in the bill. One criticism of it is found in the following extract from and address by Dr. Millikan, one of the members of the National Research Council (reads):

> "But there is now before Congress a Bill—the so-called Smith-Howard Bill—which in its original form had most unfortunate features, but which is apparently now in process of being changed into a really valuable measure. I am permitted to say that the authors and sponsors of this bill recently asked the National Research Council to appoint a committee to give it thorough study and make possible recommendations. A fairly representative committee of some ten men, including Dr. Whitney and the Director of the Bureau of Standards and the author of the bill, Mr. P. V. Stephens, has met and reported

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unanimously upon certain types of modifications in that bill. The most essential of these changes consist in the setting up of the principle, different from that incorporated in the original bill, that the funds appropriated by the federal government to each state shall be allotted to institutions within the state by a board composed of at least five of the most eminent available scientists and engineers of the state, upon the basis of programs of research submitted annually by these institutions to this scientific board. It was the judgment of the committee, and also of the executive board of the National Research Council which unanimously approved this report, that if the allotment of research funds within each state can be placed in the hands of men who know what research is, and if the institutions of a state can be stimulated to a rivalry in the development of research programs there will develop in existing laboratories of which we have already an abundance, an atmosphere of research which is now wanting. It is only through the creation of such atmospheres that research men can be developed. This sort of a plan seems to make it possible to plant men all over the country who will be creating such atmospheres. It provides for the stimulation of research throughout the country in both industrial and pure science lines much better than any scheme for federal aid which I have seen discussed."

The fact is that that bill is not likely to go through Congress, at least not for some years yet. There are so many difficulties in the way that it is doubtful whether it may ultimately pass.

Mr. WHIDDEN: Will it be possible to get copies of that bill; the bill is more important than the criticism.

Dr. MACALLUM: I have four copies here.

Mr. STEVENS: Who inspired that bill?

Dr. MACALLUM: It was introduced under the auspices of Messrs. Smith and Howard, members of Congress; but the author of the Bill is Mr. P. V. Stevens, with whose name I am not familiar.

Dr. MACALLUM: This Bill was introduced early in the consideration of what should be done for industrial research in the United States. The point of view has changed very considerably since then and that change is indicated in an address delivered recently by Dr. Frank B. Jewett, Chief Engineer, Western Electric Company before the Canadian Institute. I have copies of the address here and I would like to indicate the point of view (reads):

"I will not here attempt any long discussion of the best methods for handling research, once a supply of properly-trained investigators is assured. There was a time when the proposition of having the colleges, universities and technical schools undertake industrial research on a very large scale was much discussed. Recently such discussion has diminished, largely through a clearer understanding of the requirements for successful industrial research, and also, I think, because of a better appreciation of the direction in which the research energies of the universities can be most effectively directed for the advancement of industrial research."

He maintains that the universities should train the researchers for the industries in fundamental science.

One of the reasons that determined the council to adopt the recommendation that a National Research Institute be founded is the fact that the council itself is composed of seven university men out of a membership of eleven. They know what the situation is in our Canadian universities; they know what the situation is abroad,

and what is the opinion of experts regarding the relation of industrial research to a university, or what it should be. These members of the council, university men, were of course exceedingly anxious, if it could be at all effected, that the Dominion Government should give money to the universities to carry on industrial research work. These university men, seven including myself, know the needs of the universities. The control of the universities which is vested in the provinces, their constitution and the conditions of their environments, however, led the council to recognize, it must be said with regret, the impossibility of the Dominion Government aiding the universities to carry on industrial research. There was another factor of importance which contributed to this result. It was that the university is a home for fundamental research and that the Canadian universities are not producing enough of researchers to meet the needs in Canada. To put industrial research in the universities would aggravate the situation which now obtains and it would lead to the crowding out of fundamental research from those universities. This is an opinion which I think is of importance when you are considering what is to be done, and in support of it I would like to read an extract from an address of Professor Sir J. J. Thomson, of the Cavendish Laboratories, Cambridge, delivered before the Royal Society last November, as president of that society. He says:—

> "To increase the resources and equipment of the universities would, I think, be the most effective way of aiding research in pure science. If the grants for this have to come from a fund which has also to provide those for industrial research, there is, I think, no inconsiderable danger that the latter may be regarded as the more urgent, and that the claims of pure science may be crowded out."

The CHAIRMAN: He uses the expression "pure science" and you say "fundamental science". They are practically one and the same.

Dr. MACALLUM: Yes. Sir J. J. Thomson is one of the most eminent of the Scientific Legion in Great Britain. His standing is regarded everywhere as unquestioned, and I believe that here he expresses in very reserved language what is held by the men of science generally in Grat Britain regarding the possible results of the introduction of industrial research in the universities.

Mr. STEVENS: That merely is a broad statement. Could you give us a reason why the industrial research would have a tendency to crowd out the pure science?

Dr. MACALLUM: If you bring an industrial research problem into a laboratory it monopolizes all the attention of the place. Its importance is enhanced, because it is going to have immediate results, if successfully solved. The students themselves form a wrong estimate of the value of it, and in consequence they are inclined to disregard fundamental research. The problems themselves and the solution of them are of ephemeral value in the majority of cases. The problems change and new methods arise. In the last forty years the processes and methods of industrial chemistry have accordingly been greatly changed. Methods used thirty or forty years ago have been discarded. On the other hand the problems in pure or fundamental science, if they are successfully solved, give results which are of permanent interest and value and may open new points of view of special industrial importance. To illustrate this fact I may refer to those, for example, of surface tension. This is the force that operates on the surface of liquids and causes drops of fluid to assume a spherical form. A drop of water or of molten lead or of mercury is spherical because of the surface tension. Associated with or contributing to surface tension are forces and processes which are of the utmost importance as scientific principles but they are not as yet sufficiently investigated. They are used now crudely and empirically in the flotation process in mining in the separation of the ore from the gangue or useless siliceous matter and

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other matters mingled with the ore. Attempts have been made to improve this process but not by any fundamental research which goes back to the general principles themselves. There are a large number of experts engaged in the flotation process of separation who do not even recognize that surface tension is involved and in consequence any improvement that they seek to find is sought for only empirically. A thorough understanding of what is involved in these processes might greatly shorten all efforts at the improvement of them and might lead to a revolution in many other processes than that of flotation for surface tension or, as it is sometimes called, capillarity, is of almost universal prevalence in the physical world. A thorough knowledge of it is, therefore, indispensable in all industrial processes where physical and chemical laws operate. Now industrial research, dealing with this, does so only empirically and results in merely temporary or ephemeral gains and improvements while fundamental research, if carried on in surface tension, may, in one discovery, affect the whole industrial field ultimately."

Mr. THOMPSON: The laws of which are a continuing factor?

Mr. MCCALLUM: Yes, eternal.

Mr. THOMPSON: The application of them changes from time to time?

Dr. MACALLUM: Yes.

Mr. SHEARD: Are these proposed functions, as set out in this memorandum you have produced, in absolute and perfect accord with those adopted by the Bureau of Standards?

Dr. MACALLUM: From (*a*) to (*d*) are the functions exercised by the Bureau of Standards, of course not all in equal importance, but they are all exercised in some one respect.

Mr. SHEARD: The Bureau of Standards has done splendid work which has not interfered with the researchers, and if there be any radical differences here I would like to have them explained.

Dr. MACALLUM: I desire to speak with some reserve on this point, but my own impression is that the function listed from (*a*) to (*d*) are fulfilled by the Bureau of Standards in greater or lesser degree.

The CHAIRMAN: While we are on that point, I refer to pages 32 and 33 of this volume called "Science and Industry" which was a report issued for the English Advisory Council. It there sets out in quite succinct form the functions of the Bureau of Standards on both sides. On page 32 is the Bureau Standard side, and on page 33 the Mellon side. It gives the names of the associations with which they co-operated, etc., I think it is worth the committee's while to look at both those two pages, as it is in a sense an official document.

Dr. MACALLUM: The Research Council sympathizes with the universities and appreciates the work they do under great difficulties. It desires to see them play their part in the reconstruction of affairs that must obtain if Canada is going to carry the burden of debt now imposed on her as a result of the war, but they can only do so if they foster research in fundamental science as their main work. It would therefore be a mistake for the Council to approve of any proposition that would divert them from that duty, as it believes that the introduction of industrial research on a large scale would prevent them from doing what should be their proper work, which is the training of Scientific Researchers for Canada.

Mr. THOMPSON: Have any of our Canadian universities given full post graduate courses in science?

Dr. MACALLUM: Two only, and each partially. Toronto and McGill. Queens does not give the post graduate degree, except in the Department of Philosophy.

Our universities should endeavour to get the resources which will enable them to carry on graduate work and research. To be unable to do this and have industrial research imposed on them is to put a great handicap on them—research in fundamental science should be their chief function which is a part of education. I do not of course exclude the possibility that it may be expedient here and there to place industrial problems for research in the scientific laboratories of one or more universities. The Council's proposal would not make it compulsory for the industries to send their problems to the National Research Institute. There must be freedom allowed on that score. The Council, however, would not make any provision in its recommendations for forcing industrial research on the universities.

It has been said here, as it has been said elsewhere that if this National Research Institute is founded it will deplete the universities of their men. I said on the last occasion that the Canadian universities should endeavour to produce researchers as the American Universities are doing. There are ten American universities that have graduated 300 researchers annually for years before the war while there were not more than 20 of such turned out in the last 15 years in the Canadian Universities. They will turn out fewer of such if they give themselves over to industrial research.

Mr. SHEARD: Do you not think that if the money were given to the universities there would be very great danger of it being divided up and diverted into many channels so that it would be eaten up and no results obtained practically?

Dr. MACALLUM: Yes, there would be an orgy of expenditure, and there would be very little to show for it in the end. This would be shown if you had before you some of those who have had experience of the result of provincial aid to the universities. The Hon. Mr. Fielding, for instance who was Premier of Nova Scotia in the early "eighties" and who abolished grants to the universities of Nova Scotia in 1882, would indicate to you what would probably happen if the Dominion began aiding universities throughout Canada. You would have a force then set in action which would be difficult to curb or control.

Mr. WHIDDEN: How many American universities are carrying on industrial research work, if any?

Dr. MACALLUM: There is, I understand, some research along the engineering line carried on in the University of Illinois; there is a little carried on occasionally in the other universities. The Case School of Applied Science in Cleveland allowed industrial research to be carried on for some years in its laboratories, but the governing body and the faculty found it was so embarrassing in its effects on the work of the staff that it finally excluded industrial research almost entirely.

Mr. SHEARD: Take Yale, Harvard, Princeton and Columbia, four typical American universities, what do they do along that line?

Dr. MACALLUM: In Harvard, Yale, Princeton, John Hopkins, Cornell, industrial research is not carried on. As to Columbia I cannot say definitely. It has an engineering school, in which some research on industrial engineering problems is, I am informed, pursued.

Mr. SHEARD: What about chemical research, do you include that?

Dr. MACALLUM: Chemical research, as directly related to industries is industrial research.

Mr. SHEARD: I understand that, but original research work; for instance the extension of the knowledge of explosives. I do not know whether they are doing any special laboratory experimental work with that idea in view in connection with those four institutions I have mentioned.

Dr. MACALLUM: No. I should be glad, gentlemen, to offer some observations later on, if it is the desire of the Committee, but I would suggest that you now hear Professor Mackenzie.

[Dr. A .B. Macallum.]

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The CHAIRMAN: Does the committee desire that Dr. Ruttan should take up again the subject that has been under investigation and which enabled the Advisory Council to reach this decision? You have not touched on that this morning except in a very general way, and as I understand it, it is a decision that was not arrived at without making certain definite inquiries.

Dr. R. F. RUTTAN, M.A., Director of the Department of Chemistry, McGill University: Mr. Chairman and Gentlemen, I have had the misfortune to follow Dr. Macallum on a number of occasions and I found that in his addresses he has the habit of thoroughly threshing out the subject before it came to my turn to say anything. I find that he has done so in this case, nevertheless I may be able to give the committee some information in regard to the matters he has brought before you. My duties and activities on the Advisory Council have been very largely in connection with the problems and questions involving Chemistry. I am Chairman of the Associated Committee on Chemistry of that Advisory Board, which is composed of chemists representing every part of the country, and chemists also representing all the large universities in the country. We have met twice, once last year, and then a few days ago. At these meetings at which the majority of the chemists composing the committee attended, coming from the Atlantic to the Pacific, we have taken up a large number of industrial propositions involving the utilization of waste material, and involving the development of the chemical industries in the country. We took up last year several very important propositions; one was the introduction of duty free alcohol for the development of industries requiring that chemical for various purposes, and the lessening of the inconvenience and the red tape associated with the manufacture and distribution of methylated spirit. We found that, for instance, it was necessary for anyone who wished to obtain a barrel of methylated spirits to buy that in Ottawa, the alcohol is methylated here, and then sold. There is, therefore, only one place in Canada where methylated spirits can be obtained, so that if anyone in Vancouver wanted to buy a barrel of methylated spirits he would have to get it from Ottawa, although at a distance of a very few miles away, in New Westminster, there was a distillery where the alcohol was distilled, that, technically, had to be shipped to Ottawa to be methylated and shipped back. That is just an illustration of one of the things we ferreted out in connection with chemistry, because that should be remedied. We brought these matters up and had a bill drafted which was distributed recently to the House, and is now being held up for some information. We advised the Research Council to study the value of the waste fish and fish waste of the Dominion, and how it could best be utilized. We found that there were approximately 250,000 tons a year of waste fish and fish waste of which probably 150,000 to 180,000 tons were available for manufacture into fertilizer, or into stock food and poultry food. Our representative chemists in British Columbia and Nova Scotia made extensive investigations. They corresponded, as I did also as chairman, with the large fishing interests, and we obtained their opinion first as to the amount of fish waste that was available, and secondly, whether they would be interested in having an industry established for the utilization of this waste. We got most encouraging answers from nearly all the fishery men, and subsequent investigation went to show that the Conservation Commission had already looked into this matter as regards inland fisheries, and had employed Mr. J. B. Fielding to make some simple experiments on Lake Erie on a small scale. Owing to inadequate equipment, and to want of time, very little was accomplished. The results were not satisfactory either to him or to the Commission. He is, however, a recognized expert in this field and the only one we had in Canada in connection with that work, so he was asked by us to make a port survey of Nova Scotia and New Brunswick, and report. He did so and at Canso, at Grand River, Gaspé, and one or two other points, found that it would be economic to establish units for the manufacture of foodstuffs for cattle, hogs and poultry, as well as of fertilizer from the fish waste. A number of other places were out of the question because the material was so scattered that it would not pay to

collect it. Thus we succeeded in crystallizing the matter. We obtained the exact figures, and we were able to present to the government a statement that with a grant of $50,000 we would be able to establish a demonstration plant which would show the fishermen on the one hand, and capitalists on the other, that there is a profitable industry to be built up from fish waste. This matter was brought before the Department of Marine and Fisheries and the Food Commission by the Council and it was submitted to two or three other Commissions all of which agreed that it was a magnificent idea; but that was as far as we got. We went before the Committee on Reconstruction, and it was discussed by them but they could not even give us permission to use $50,000 of our own money, with an opportunity of returning it. It was in 1918 and this matter looked very small compared to the great war problem. In the meantime, we had been doing a good deal of publicity, and investigation, and we are still receiving letters from places throughout Canada asking about the utilization of fish waste. Mr. Fielding, Mr. Meyers, of Woodstock associated with some others from Western Ontario and Nova Scotia have established a company now and have put $100,000 into the industry for machinery alone. They have obtained from the government one of the lobster hatcheries, at Canso and the first factory is practically established. I am pleased to inform you that this important industry has been recently launched through private enterprise. I could point out a number of other industries that we have attempted to develop. Take for instance, the manufacture of ethyl alcohol from waste sulphite liquor. We investigated that. The research work in connection with it was in part carried on in my own laboratories, and we demonstrated that the waste liquors from the sulphite pulp mills of Canada was just as valuable, for the production of alcohol as the sulphite liquor which is produced and used in the United States and Sweden for the same purpose. Everything was arranged for this matter to be taken up by two of the larger mills in Canada. They spent a great deal of money in investigating it from a business point of view going into the matter most thoroughly, and they were able to satisfy themselves that they could produce alcohol at from thirty-two to thirty-five cents a gallon, that is ninety-five per cent alcohol, and could enter into competition, and active competition, with the alcohol which is produced from grain or molasses and other waste products. Our object in bringing this matter forward was to try to prevent the utilization of foodstuffs for the manufacture of alcohol. We found out the quantity of alcohol that is used for industrial purposes in Canada, and we came to the conclusion that all the alcohol necessary for industrial purposes in Canada could be made without using an ounce of foodstuffs. From such sources as sulphite liquor waste, blackstrap, i.e. waste molasses, or wood waste, we found it would be possible to manufacture all that would be required at a comparatively low rate. From the sulphite liquor waste in the St. Maurice Valley alone, we estimated that it would be possible to supply all the industrial alcohol that is used at the present time in the country for purposes other than those of explosives. Further development of this industry depends upon the size of the market for industrial alcohol which can only be estimated by removal of the excise duty. This same Committee took up the activities of another branch which I think has been touched upon by Dr. Macallum, and brought forward the idea of establishing a chemical census in Canada, that is a census of all industries which are chiefly concerned with chemical processes in connection with their activities; so that the manufacturer of one product would be able to know what the waste products of another manufacturer were. He would be able perhaps to find a market for his own by-products and know what materials are manufacturerd in Canada. That census is in course of preparation. It being prepared from the Bureau of Statistics with the assistance of the Associate Committee of Chemistry and the Society for Chemical Industry in Canada. This Associate Committee of Chemistry has also been very active in bringing together and unifying the chemists of Canada. At a meeting held

not more than three or four days ago in Montreal, all the chemists, from the Atlantic to the Pacific, formed themselves into an association to be known as the Chemical Institute of Canada, an organization which I think will have far reaching effects in bringing about co-operation in chemical research work throughout the country. We have been very glad to be one of the prime movers in this connection, because there was a possibility of two or three different chemical organizations being established in Canada which would be more or less antagonistic and which would not have led to that friendliness and co-operation in a branch of science that is very essential to scientific progress. Dr. Macallum has referred to the activities in connection with the assisted researchers. I understand he has gone into it very thoroughly. I am also chairman of the committee, and we were rather disappointed at the number of men who came forward in answer to our request for problems. There were very few. It was one of the most disappointing features in connection with our work. This was due very largely to the great research activities in connection with explosives and munitions. Industrial research was put in the background for the time being. We expect to have more applications in the future. We have had a number of applications, some of them perfectly impossible, of course. We have been accused of being arbitrary in connection with granting these sums of money for assisted researching, and in case that statement is made, I would like the committee to know exactly how we proceed in that connection. There is a committee of the Advisory Council consisting of four members, and an application for assistance in connection with research is sent in.

The CHAIRMAN: Is this a studentship or a fellowship?

Dr. RUTTAN: No, assisted researchers for others than students and fellows. A man says he has a possibility of developing a process or preparing a useful product along a certain line, and wishes to continue. It will cost him a certain amount for assistance and materials which he cannot afford. That proposition is brought before us. It is manifolded and sent to each member of the committee. Each one replies, and then if necessary experts from the outside are consulted in connection with this proposition, and decision is reached for or against his proposition, after the report has been considered by the whole council. The general question of research has been so thoroughly gone into by Dr. Macallum that I think very few words, or a very short synopsis from me is all that will be necessary. The first object of the Advisory Council was to create a background of public opinion throughout the country which would appreciate and support the idea of research in general, and especially of industrial research. This we carried out by the publicity in connection with the scientific and other publications of the country, and also through addresses given in cities at the various Canadian clubs, boards of trade and labour organizations, etc., throughout the country. We succeeded in stimulating interest in the universities, the various scientific and technical organizations throughout Canada, if anything we overdid it, so to speak. We created so much interest that there has been an active controversy as to the details and as to the best way to carry out research. So that we felt that to carry conviction to every class in the community, from the universities to the labour organizations, it was necessary to bring forward some definite and workable plan or proposal. To formulate such a plan was no easy matter. We made a careful study of the literature—and I can assure you that the literature on the subject is enormous for the movement is a worldwide one. We looked into the work that had been carried on in Great Britain, in France, in all the colonies, and in the United States. All information on this subject that came into the Advisory Council was manifolded and distributed to each member of the Council, was read and discussed at our meetings. In addition to that our Chairman, Dr. Macallum, visited Washington alone, and afterwards we went as a deputation of five, ond visited New York, Washington, Phila-

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delphia and Pittsburg, spending one day at the Mellon Institute. There was a lot of research operations going on everywhere and we saw many of them. While in Washington and Philadelphia, we met the majority of the leaders of organized research in the United States. We conferred with them as to the best methods of developing research in Canada. Many of them said that they wished they had the clean sheet that we had, because in the United States organization of research was complicated by the number and variety of industrial and scientific research organizations now existing. It was impossible to unify and organize them so as to prevent overlapping, duplication and friction. Probably one of the greatest authorities, Dr. Stratton, the head of the Bureau of Standards, stated that if they could begin again they would have the one central organization instead of having a geophysical laboratory, a chemical bureau and numerous other laboratories, as well as the Bureau of Standards and research institutions in connection with the Department of Agriculture and the Department of Food, all doing research in an independent way. One national organization for research, in addition to the departments of the United States Government, doing routine scientific work, would lead to the best results. We found that this was confirmed by a number of others at the various discussions that we carried on.

The first problem in any step in developing research in Canada and the one I am more intimately associated with, probably more than any other, is to find and develop the men i.e. to breed researchers. The universities must be the source, not only the main source but practically the only source, with perhaps advanced technical institutions, such as we have not got in this country. We must look to the university for men who are capable of advancing knowledge in connection with the industries and scientific research generally in the country. They require special training. The university turns out graduates in the various departments of science, who go through a prescribed course of four years, and during that course they receive careful instruction and a certain amount of training. They are informed regarding the facts and theories of their particular branch of science, and they receive a certain amount of laboratory training in the different departments of experimental science. When these men finish they receive a degree, which, in the public mind, establishes them as men who are capable of carrying on the service. That is one of the most unfortunate things for the country. The popular idea is that because a man is a B.A. with honours in chemistry or physics, therefore he is capable of carrying on research. This is unfortunate because the manufacturer is discouraged by the failure of his chemist; for instance, to realize his expectations and it is quite unfair to the universities. The undergraduate during his course, is absolutely dependent upon the instructions of his teacher and text-books and his laboratory guides for his work. As a student there is so much to learn, and the time is so short that it has been the experience of the universities that it is impossible to do much in the way of broad education and fundamental training in research during the period of four years. The Advisory Council recognized that it was necessary to have post-graduate study working along definite lines of research, that research being of such a character as to give broad knowledge in fundamentals in the particular branch to fit a graduate to undertake responsible industrial research. The object of this graduate training is to throw the young graduate on his resources for the first time; to teach him the use of the means at his disposal to get results; how to find things in the enormous mass of literature which is available in every branch of science. It takes the best part of the first year of graduate training to get a man to find his way about in the literature of his subject. I need not go into the details but I can assure you that it is something very difficult to attain a sense of responsibility in his observations. If a student goes wrong in a bit of work in the laboratory the error is soon discovered and rectified; if he goes wrong in one of the steps of research he is probably going to ramble a long way afield before he finds his way back. Hence he finds out the advantage of being

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extremely careful in his observations and the responsibilities connected therewith, which he never feels as an under-graduate. And then another point is that, when they leave the lecture rooms and go into research work they come to appreciate how important it is to disregard authority, to take nothing for granted but to be independent and to think for themselves. That is one of the most difficult things to instil into one of our young men who has just graduated, some never acquire it and fail as researchers. And then there is originality; of course this is new to him. He has to meet new conditions unassisted, he will thus acquire mental dexterity as a result of experience. Now, gentlemen, this is rather pedagogic in tone but I have taken this up to point out to you that the technique and mental attitude necessary for research are not easy to import to the young graduate. These qualities cannot be fully acquired by working along a narrow field of research and concentrating his effort on getting a so-called practical result. They are obtained if at all when he tackles a fundamental problem that involves the necessary use of wide technic and a knowledge based upon three or four of the subjects with which he has been connected during the early part of his career. In other words it is the universal opinion, I think I am right, of those who have had experience in conducting a graduate school that the broad fundamental problem is the only one which leads to first-class results in the way of training. I do not know whether you know that we have 12 men engaged in research in my department at present engaged on problems in biological chemistry, in physical, organic and enzymic chemistry. The five young graduates are working at problems which are not necessarily economic or industrial but many of them are such that the results are not only of scientific value but may soon lead to something of economic importance. Not only are the professors in charge of research in our own universities convinced of the value of academic research, in preference to industrial research, but those in charge of the large industrial research organizations have come to appreciate that the best men they can get are not the men that have been trained along their own line, but the men who have broad university training. A very remarkable example of that was quoted at the last meeting of our associate committee on chemistry by Dr. McIntosh, of British Columbia, who is in very close touch with industrial research in the United States, and who saw a list of applicants, some 12 or 15 in number, for the position of research chemist in connection with, I think it was, a company on photography. Many of these men had already done research work on photography, other men had received training on branches of science bearing on photography, and Dr. McIntosh asked "Which one did you select?"; "I selected this man at once" was the reply, and Mr. McIntosh inquired "What has he done?" The reply indicated that he had spent three years in studying where crystallization commences in a saturated solution. Could anything be more thoroughly academic or apparently useless than such work as that? yet this man of experience in conducting a large research institution selected the candidate who had no previous experience in that particular line. Why? Because of the training this man had to go through in order to get the results he had obtained was far better than industrial work on subjects immediately kindred to photography. Let me cite a case in one of the great industries in the West where they had been depositing zinc by an electrolytic process. It was found when a certain ore from a new mine came in the solution which was made up of from 5 to 7 per cent the zinc would not deposit. They tried different strengths of current without any result, and they tried different strengths of solution but the zinc would not go down. A very careful analysis of that ore showed that there was about a ten-thousandth of one per cent of nickel and cobalt in it which was not in the ores they had been using. Now, any one who knows anything about analytical chemistry knows that you cannot by ordinary economic processes get rid of one ten-thousandth part of one per cent from zinc. But fortunately in that laboratory there was a man who knew nothing about zinc, and nothing about cobalt and nickel except

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that in a very general way he knew the principles of analysis; but he happened to know something about the absorption and of surface energy to which Dr. Macallum referred. So he asked himself, what can I throw down here that will pick up this trace of cobalt and nickel and carry it down, and by a process of precipitating one of the other constituents of the ore the one ten-thousandth of one per cent was removed from it by colloidal action and that ore became ordinary, and that mine became workable. That was done through the kind of work that is laughed at by the average industrial chemist as so absurd that it ought to be relegated not to chemistry but to a field of science where scientific imagination plays the chief part. I could multiply these examples by a great many others, but I would like to point out that these are serious difficulties in the way of the universities turning out trained researchers. We have not in Canada enough of the men who are necessary for the development of industry. To obtain them our universities must be more richly endowed with facilities, with equipment, and with men, chiefly men, because equipment is of comparatively secondary importance in a great many branches. It is more important in physics than in chemistry, and after the universities are more fully equipped we will be able to send out the required number of well trained men. The universities must receive money from somewhere. Dr. Macallum has explained, and I wish to heartily endorse what he says, that it is not practical to supply money to universities with a general remit that it is to be used for research purposes. In the next place—and I speak with knowledge in regard to this point—it is almost impossible for the head of a department engaged in research to confine the money which has been given to him to assist research to that particular work. The demands for teaching are so great; the demands for organization are so great, that that money must invariably, directly or indirectly, be applied to uses other than those of pure research. It is almost impossible to prevent diversion of the money. The universities must get special endowment in connection with research, and it would with much better grace come from the public, from those who support the universities, or from the provinces, than it would from the Federal Government, there are so many universities, eighteen or twenty as Dr. Macallum has pointed out that would apply for this grant. With the view of assising in this research and graduate work we have established fellowships, scholarships, studentships, and recently bursaries, the object being to help the universities to get the men. But the universities must supply the money for the training. I think that the universities in Canada will this year have more students to train in research than they can possibly look after, and this is only, as we hope, a beginning. An arrangement has been made by the Advisory Council to establish a travelling fellowship in memory of the late Sir William Ramsay, so that we may be able to send one man to England each year for special training along the line of chemistry. What are the inducements for graduates to take on this special and advanced training? Some years ago we could not advise graduates to take up research as a life's work. There was no market for that type of man practically in Canada, and the market in the United States was comparatively small. The best of the men went to the United States, and we got none. Now there is a different state of affairs. In Canada there is a market for a large number of well trained men. I will give you one example though I could give you others. One of the biggest industries in this country is the manufacture of paper and pulp. We have an enormous capital invested in that industry. There are mills all the way from Labrador to British Columbia. Do you know how many Canadians there are in charge of the expert work in connection with these mills? There are only two; in fact there was only one until quite recently when another one was appointed. We have not trained the men, with the result that those in charge of the technical work, especially the chemists in the larger mills throughout Canada, come from Norway, Sweden and the United States. We have only one, or perhaps two, who are Canadian graduates. The question of how research should be carried on in larger industries is comparatively easily settled,

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because the manufacturers are all alive to it, and the paper and pulp and other large industries are asking for help. They want the men. The Shawinigan Falls Company have recently established a research laboratory to deal with four or five of their large industries there. They searched Canada with a view of finding research chemists and physicists. They have one temporarily from my department, and there are two others who are in secondary positions and they will probably be obliged to go to the United States to get their head men in chemistry and metallurgy. Dr. Macallum has taken up the question of the formation of guilds as a method of bringing about research in the smaller industries. It seems to me that we are justified in expending money in that way, and chiefly, and best of all, through the research institute. It seems to me just about as fair to ask a farmer to make researches regarding the best kind of wheat to grow on his farm or the best fertilizer for his soil, as it is to expect a small manufacturer to go into research in connection with his particular industry. The Government aids the farmer with a good liberal grant through the various experimental farms, and the Government should also, in my opinion, help the industrial organization, which is working in a small way, and the best way of carrying that out in my opinion is by means of a central organization, which will supply to the expert connected with a guild the necessary laboratory accommodation and equipment, and charge only a moderate rent, or none at all, for the use of more elaborate apparatus, the guild simply paying the expenses of the technician. This is the plan of the Mellon Institute at Pittsburg. That matter has been thoroughly gone into by Dr. Macallum, and I will not take up any more of your time on that subject. I would like very much at some time or other, if you deem it necessary, to go into other phases of this question, particularly in connection with the relative value of industrial and scientific research in university training.

The CHAIRMAN: You spoke of your deputation going to the United States and your investigations there. Do I understand that the university side was gone into? Was there some one to speak on behalf of the idea that universities are the proper place for industrial research?

Dr. RUTTAN: As I remember at these meetings in Washington both sides were pretty well discussed. We had with us a strong champion of the university side of the work, a member of the Advisory Council, namely Dr. Kirkpatrick, of Queen's University, and he brought up the question at every meeting and on every occasion, and he occasionally received a certain amount of support, but the general concensus of opinion was that research should be organized and centralized when applied to industries for industrial purposes, and in the universities to be carried on chiefly for scientific purposes. Dr. Carty, a great authority in connection with telephone work in the United States, was strongly in favour of the Central Research Bureau, and of training through abstract science in universities.

Mr. THOMPSON: Have we facilities in our Canadian universities for housing departments for industrial research?

Dr. RUTTAN: Not at present. Industrial research or industrial investigation develops from ordinary laboratory investigation in this way. It passes through, you may say, three stages. First, there is a small scale carried on at the laboratory bench or in the laboratory glass with materials of that sort, and if this preliminary investigation is not still-born there it passes to another stage which we call the semi-commercial stage, and there is where the mortality is highest, and then it comes to the commercial stage afterwards. Universities are not equipped to carry on the intermediate stage where the value of processes are actually proven—the semi-commercial stage. That can be only carried on with advantage in association with a plant or such an institution as the Mellon Institute or the Bureau of Standards in Washington or a central research institute.

Mr. THOMPSON: Suppose a central research institute were established here in connection with the Bureau of Standards dealing with the plan you suggest, would that organization give a field for our post graduate men to operate in which we have not now?

Dr. RUTTAN: Yes, it would be one of the prizes to be sought for by our graduates. It would give an opportunity of keeping advanced scientific men at home. We would expect that the men who pass out from the university laboratories well skilled in research would be taken up by the research institute, and then drafted from the research institute into the various industries.

Mr THOMPSON: One was mentioned particularly in regard to science, and the pulp industry was referred to. It might be possible, through the Central Institute to obtain men who would be capable of doing research work in these industries.

Dr. RUTTAN: Yes. You might get special research men in connection with paper and pulp, but better from the Forest Products Laboratory if that is once more put on its feet by being properly staffed. The training there should begin after graduating from the university, after having received a general scientific training, specializing on the paper and pulp industry and applying their fundamental knowledge to this industry, you could expect to get valuable men. The great trouble with pulp and paper in Canada is, not the quantity we are turning out—because we are turning out a tremendous lot at a big profit for the country—but that we cannot compete in the export trade with the highest grade of pulp made in England and Sweden until our pulp is many degrees better than it is to-day. That is thoroughly well recognized, while our mills are turning out a good commercial grade of pulp, authorities on this question of paper and pulp, agree that the quality of paper and pulp they are turning out is vastly inferior to the more valuable high grade paper and pulp which they produce in England, Norway, Sweden and the United States; and the reason is that they cannot obtain university men of sufficient skill and scientific training in pulp and paper technology. It is our hope to be able to provide them in the near future.

Mr. THOMPSON: We have the wood for making the finer quality of paper. It is merely a question of technique.

Mr. WHIDDEN: Why should not the pulp and paper manufacturers establish their own industrial research laboratories as they do in the States? There are small concerns in the States conducting industrial research for the sake of their own business.

Dr. RUTTAN: The paper and pulp industry was prepared some time ago to unite and contribute a liberal amount each year for the maintenance of research in connection with that industry. They could not come to an agreement with the Government in connection with the conditions under which they were to use the forest products in the laboratory in Montreal. They considered employing two or three experts for research in pulpmaking and paying them proper salaries not two or three thousand but five or six thousand to high class men to carry on the research work. It seemed impossible at the time to come to a satisfactory arrangement with the Government regarding the use of the Forest Products Laboratory.

Mr. THOMPSON: I would like to ask you as to whether we are doing anything in the way of utilization of waste products from our saw-mills, particularly sawdust?

Dr. RUTTAN: A great deal of work has been carried out of a preliminary character in that connection. The Chemistry Committee reported on a process which was brought out by a Mr. Tomlinson, and which is now being utilized in the United States in the manufacture of ethyl alcohol from sawdust by a certain process of hydrolysing it with acid and getting alcohol from it. If that process had been going on during the war, at the high prices which were paid for alcohol, it would undoubtedly have been highly profitable. The success of that process depends upon the length of the season and the amount of available raw material at a very low price. Alcohol can be made

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at about twenty-five to thirty cents a gallon from sawdust, and one cord of sawdust, or one ton of sawdust will produce about four and one-half gallons of 95 per cent ethyl alcohol, and yet it does not seem possible to apply that in Eastern Canada, because the season is too short and the cost of transporting the raw material is too great. Sawdust must be delivered into the hopper at fifty cents a ton in order to produce the ethyl alcohol at a rate of twenty-five to thirty cents a gallon. That process has been carried on in Louisiana, and they have produced 4,000 gallons a day. It is being carried on in Georgetown, North Carolina, at the Dupont Powder Company, 2,000 gallons a day; both of these propositions were established by Mr. Tomlinson. The only attractive field for this industry in Canada is British Columbia, and I am in hopes that the time is not far distant, if there is a market developing for industrial ethyl alcohol on the Pacific coast, or near there, that we will have a profitable alcohol industry from wood in British Columbia. There is plenty of material near at hand and the season lasts for twelve months; it is only a question of transportation of the alcohol to a market.

Mr. THOMPSON: Having in mind the gradually increasing cost of gasolene, and also the increasing use of gasolene, I would like to ask Dr. Ruttan, if in his judgment, a market could be created here that would be commercially profitable for the making of industrial alcohol from sulphite or distillation of wood, or other waste products?

The CHAIRMAN: With an internal combustion engine?

Mr. THOMPSON: Yes.

Dr. RUTTAN: Ethyl alcohol at present is too expensive a material for internal combustion. I have forgotten the name of the mixture which is now put on the market by the industrial corporations of the United States. It corresponds with another product which is called alco gas, which consists of about 40 per cent of ethyl alcohol, a small quantity of ether, some common petroleum and some benzine. I do not recall the exact proportions and this material is now being supplied by the Industrial Alcohol Trust in the United States, at prices that compete with gasolene, viz., at about twenty-two or twenty-three cents a gallon. They claim that they are not losing money. So that it looks very much as if some of these mixtures in which alcohol plays an important part will soon be used in direct competition with gasolene.

Mr. THOMPSON: Is acetone used in the manufacture of other things besides munitions?

Dr. RUTTAN: Very little, except as a solvent.

Mr. BELAND: Is the mixture you refer to as efficacious as gasolene for motor use?

Dr. RUTTAN: It is claimed to have properties identical with that of gasolene, with this exception that it cannot be used in cold weather. There is too much heavy oil, too much benzine in it, and it cannot be used in aeroplanes for the same reason, but they are now devising a mixture containing more ether and less benzine which can be used in aeroplanes.

Mr. THOMPSON: You spoke about black-strap being one of the sources from which alcohol could be made. Do we produce much of that?

Dr. RUTTAN: No, we produce very little. We have the sweet waters from the sugar refineries, but we have to import this black-strap. The black-strap is the molasses left from crystallized sugar in Cuba in the West Indies and Louisiana. Before the war, before the demand for alcohol arose, this black-strap from Cuba was used as fuel. The molasses was run out into a huge pond and allowed to evaporate in the sun until it became thick enough to be put into the furnace with a spade, and then it was used as a fuel for the furnace, they were delighted to obtain 2½ cents a gallon for molasses that had over 50 per cent of fermentable sugar; now that is worth 15 cents a gallon.

An hon. MEMBER: I understand that a by-product of the coal tar gases of Nova Scotia has been developed which they are using for their automobiles.

Dr. RUTTAN: There is a by-product from coal tar distillation where recovery ovens are used which could undoubtedly be substituted for gasolene.

The Committee adjourned.

WEDNESDAY, May 21, 1919.

The CHAIRMAN: Dr. Ruttan, who was here yesterday, is with us again to-day, and I should like to ask him a few questions that I noted down in the course of his remarks. The first is, you emphasize, Dr. Ruttan, the need for the universities finding assistance in the matter of pure fundamental research. I would like to get your idea as to where that assistance should come from.

Dr. RUTTAN: Pure research should be part of the regular system of education in a well organized university. It is graduate instruction and graduate training, in counter distinction to the ordinary student's education. It therefore comes under the head of education, and it is a dangerous thing for an organization like the Honorary Advisory Council, connected as it is with the Dominion Government, to subsidize a form of education which really belongs to the provinces. Research is a different thing, but the training in the university which is brought about by research is educational; and I think the aid to that should come from the provinces, or from private donation, and not from the Dominion Government. I can assure you, sir, that there is nothing personal in this. I would rather have for my own Department a liberal grant to aid in training for research, but as a member of the Advisory Council I would certainly not feel justified in voting for it.

The CHAIRMAN: Something was said about the necessary equipment for research in the universities, and for industrial research. I think it would be well perhaps if you would explain a little more elaborately, the difference, if there is a difference, between the respective equipments necessary for these purposes.

Dr. RUTTAN: Speaking for chemistry, the equipment for research work on academic lines is comparatively inexpensive, once a university has been properly equipped with the fundamental apparatus for exact measurement. In industrial research, the preliminary steps, the bench work, is not more expensive than academic research. But the semi-commercial school in which all industrial research must be carried on requires a great deal of space and very expensive apparatus and equipment.

The CHAIRMAN: You were asked, as I recall, whether it was not perhaps the duty or function of the larger industries in Canada to establish research laboratories. Can you tell us what has been the result of following that course in the United States in the larger industries?

Dr. RUTTAN: As Dr. Macallum has stated, they have established a large number of laboratories, costing anywhere from $50,000 to $500,000 a year in the larger industries, and, of course, the result of that has been to put an immense amount of power in the hands of these large industries. They are bound to go ahead more rapidly than the smaller industries, and very often they acquire patents and secure processes ahead, and keep them locked up for future use; so that in the event of any of the smaller industries making an advance they can realize those processes and continue to hold their own. At the same time, it is a very difficult question for the

country as a whole to decide whether it is in the interests of the development of the country and of the increase of its riches. One of the large corporations, such as developed in Germany and such as are now being developed in the United States and in England, would not aid very largely in increasing the resources of the country. At the same time, it tends to monopoly.

Mr. NICHOLSON: Is there not a very great possibility in that connection where large industries develop and secure processes for the more economical use of potential wealth, that in order to protect an obsolete process they might lock up the new processes and prevent their development?

Dr. RUTTAN: That has been known to occur.

Mr. NICHOLSON: I have in mind one instance where it is said that one large institution in this country has secured the patents on a process, and has simply tied it up in order that the investment they had made in a more or less obsolete process may be protected against the use of a modern or more highly developed process doing the same work, and the result is that the country as a whole is losing to that extent.

Dr. RUTTAN: I can imagine that that might occur, but I do not know of any examples myself.

Mr. MCGIBBON: It could only occur in cases where it would involve enormous expense to turn over from one process to the other?

Dr. RUTTAN: Where it would be more economical to keep to the old process with their equipment and plant than to tear down the whole plant, rehabilitate it and begin a new process.

Mr. MCGIBBON: I gather that your idea of solving these possible difficulties is for this research work to be done by the Government, that the research should be conducted by the Government instead of by corporations.

Dr. RUTTAN: The development of research and scientific organization in the smaller industries should be helped by the Government; that is my position. It should be helped through such an organization as we propose, namely, a central research institute, with its associate departments corresponding to the Mellon Institute, and so on. The larger and wealthier organizations can be trusted to recognize that research pays, and they would be perfectly willing to establish their own research laboratories. But to give the smaller manufacturer an opportunity to compete, the Research Institute would play a very important part in the development of industries in Canada.

The CHAIRMAN: If there are no other questions we will excuse Dr. Ruttan. We have with us to-day Dr. Mackenzie, President of Dalhousie University.

Dr. A. S. MACKENZIE: Mr. Chairman and Gentlemen: it is a little difficult to know where to begin on this matter; as doubtless Dr. Macallum, whom I did not hear in his early remarks before the Committee but whose supplementary statement I did hear yesterday, and Dr. Ruttan have covered the ground pretty thoroughly. I shall therefore try to be brief. First, I shall give a résumé of how I came to the conclusions that have been voiced by the Council in general in the proposals which they laid before the Privy Council, which will cover some, or most of the arguments, and later deal with one or two other points. I have no doubt that Dr. Macallum made very clear to the Committee the need there is for research facilities in Canada. I have no doubt that he made it quite clear that Canada is almost unique among countries in the lack of facilities of this kind. If we take our population as 8,000,000, and compare Canada with any of the other countries having a somewhat similar population, such as Portugal, Spain, Holland, Belgium, Denmark, Sweden, Finland, and even some of the South American countries, we shall find probably that we are the only country that has not at least one university where a student can go for a full

graduate course in almost any department, and that probably Canada is the only one of these countries that has no adequate university or Government research facilities. Therefore, as a nation we have very little to be proud of with regard to our standing in what might be called the most advanced regions of educational work, in which I include, naturally, research. I think that that statement is not too strong, namely, that as compared with other countries, though we very much dislike to rank ourselves below them, we lack to a very striking degree those institutions, whether universities or research institutions of any kind that a country should possess. So that when this Research Council was formed, and we were given by Order in Council the problem of how to improve and encourage and advance scientific and industrial research, we realized that the task was a tremendous one. The whole problem has to be undertaken from the beginning in Canada where there are no universities properly equipped for research nor any institutions worth speaking of devoted to research in the larger sense. Probably we ought not to find too much fault with ourselves for this condition of things. That we have no one university thoroughly equipped and staffed for complete study and advanced work in all directions is probably due to the fact that our educational system is provincial, and not federal. If we had education as a federal problem, I have no doubt, that the natural and proper pride of the people of this country, as expressed through its federal Parliament, would have shown itself in the erection of at least one university in this country that would compare with such a university as you would find in Holland, Sweden, Belgium, Norway, Spain, or any other country of about our own magnitude. The matter being left to the provinces has tended to a multiplication of smaller universities. That may also have had its great benefit. I am not arguing for one as against many, as at present; but the fact that we have had no general federal educational system, I think, has prevented the foundation of at least one strong, what you might call state, university. In the problem with which the Council was faced, to provide research, or foster research facilities—where are you to begin, when you have almost no nuclei, except such as exist at two or three of the present universities. The difficulties would be obvious, without a moment's thought, and you can see that the Council would have been very unwise had it attempted to find an answer to the question in any hurried way. It has taken the first two years of the Council's existence to come to a more or less unanimous conclusion as to what we should do first; it has been the one matter, I suppose, that has come up at every meeting of the Council since we began our meetings in December two and one-half years ago. Naturally I think one of the first things that would occur to any one would be this: there are universities, some of them having some scientific research facilities; had we not better start with these as existing nuclei? However, we were formed in the midst of the war and war problems, which necessitated, if anything ever did, a call for industrial research; and the development of industrial resources, and our obvious sense of the coming commercial struggle, where industrial advantages would mean so much to this country, gave us a swing in the other direction; so that at the same time as we felt that we ought to deal with the universities as existing nuclei, we had right before our eyes this problem of industrial research as the one needing the quickest attention. That led us to study the thing as fully as it was possible in order to find the best way of doing it. After a good deal of consultation among ourselves as to what we already possessed in the way of research facilities, and after familiarizing ourselves with the literature and written opinions, we, as Dr. Macallum mentioned, made, first through the chairman, and then by a large delegation of the Council, visits to various institutions across the line, and had several very important meetings with gatherings of scientific men, both university men and men whose main interest was in the industrial research; and I would like to speak particularly for a moment about the meetings which we had in Washington. Washington is not an outstanding scientific

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centre in normal times. There the Government Bureau side is well developed; but the great commercial scientists, and the university scientists, as a rule, are not in Washington; but during war time when we were there there was gathered together practically all the scientific forces of the United States. So that we got there the most advanced and most able men in university work, in industrial work, and in the Government Bureau work. We had two meetings on two successive evenings, with twenty-five to thirty on each occasion of the most prominent scientific men, I would say, in all branches of scientific work. They were exceedingly generous in their attitude toward us, because they did not ask us to take up their problems, but they very fully gave us their opinions on our problems, and they discussed those problems from all phases, whether to attach industrial research work primarily to the universities, whether partly to the universities and partly to some outside agencies, it should be quite separate from the universities. Every side of the question was discussed, and there were advocates of all phases. I think it is only fair to say that the almost unanimous opinion and advice given us at these gatherings was that for us in Canada, with very little, almost nothing, as I say, in Canada, with very little, almost nothing, as I say, in the way of research centres developed, the best thing was at least one central kind of research institution where we could have almost any piece of research undertaken. I want you gentlemen to realize that we did not at all start out with any pre-conceived solution. All sides of this problem were represented by pretty strong advocates in our own body at the start, and we went away with minds thoroughly wide open. We came back without any definite decision as a Council, and for another eight months or a year we have discussed this matter until we have reached practical unanimity in the Council as to what is the best thing for us to do first, accenting the word "first"; because I think it is easy to run away with the idea that the general suggestion the Research Council have laid before the Government has some finality or is a sort of final solution of this problem, and I would like to lay very much more stress on the fact that this is merely the first step that we have suggested. Now, to come back to another phase of it—and I think this will complete my historical review—the first thing that was brought up before us, among ourselves, in the way of meeting the industrial problem which was urgent on account of the war, and also would be urgent after the war, was a suggestion that we might start in the manufacturing centres—Montreal, Toronto, and Winnipeg were instanced at the beginning,—bureaus with small laboratories, with information departments and libraries of technical science, something that you could build rather quickly and install without too great an expense, and seemingly that would be of immediate value to the industries in those particular centres. We worked at that quite a while. It was somewhat connected with the fact that probably in such centres there also would be universities—those three of course would have universities—and that there might be some co-relation or co-operation between those research and information bureaus and the universities situated there. On the face of it, it had certain very strong arguments to support it. We thought out this scheme and worked it out thoroughly. We never carried it beyond our final formulation, because we ran into this difficulty, that if we put such a proposition before the Government we would find that it would be considered as interfering with the provincial rights in education. Therefore the only way in which it could be done at all, seemingly, would be in a similar way to that which the Government adopted towards the agricultural development of the country, through a grant in aid, supplemented perhaps by a similar grant from the provinces, and distributed and utilized under federal supervision. It was no sooner seen in that light than it was evident that the demand on the Government from all sorts of centres would be so insistent that they would not consider it. In fact, some suggestions were made to

some members of the Privy Council, under whom we worked, and it was perfectly obvious that these difficulties presented themselves so very forcibly to them that they said no government would lay itself open to the pressure which would be brought to bear. However, we had about that time reached the conclusion that that was not a solution, for this reason: these bureaus would have to be small because there would be many of them. But it would mean that very soon, the problems that would be laid before them by the manufacturing and industrial concerns would require for their working out an equipment and development that had not been provided, and therefore it would mean that the demands from each would grow greater and greater. You might put in first a few chemists and a few physicists, but very soon you would require to have a special chemist for every phase of chemistry, bacteriologists, and so forth. Greater facilities would be required and the cost would gradually increase, and that would apply not only to one place but to every one of those centres. You could not do for one that you were not prepared to do for all. It was clear that that would lead to tremendous extravagance and duplication and waste. Having practically reached the stage of eliminating that way of doing it, the question came to be practically one of helping the existing universities which might act as nuclei, or of providing some sort of research institution apart from these. Now the same arguments which I have just used, and which I think it would be unfair to take the time to go into again, led us to realize that to subsidize the universities for research was not a solution that we could place before any government. You will realize that a Research Council, constituted as ours was, with a large representation from the universities, in fact consisting to the extent of more than 50 per cent of men connected with universities, had to look at any suggestion concerning them carefully. It was very easy for the selfish side to creep in. Universities are just as selfish as any business corporation; and as the head of one of these universities, I fear that we cannot ever say that university presidents are any freer from the selfish side than the heads of other institutions. It was therefore incumbent upon us to look at the question so far as it related to the universities pretty openly and carefully. It would be very easy again for a university head to say: We had better ask the Government to give a grant; we need it badly and we could use all we can get. Dr. Macallum pointed out that there were 18 universities and colleges in this country, and I think he was very modest in his figure, because I come from a part of a country that is so over-supplied with colleges, that we have half that number there alone. In the province of Nova Scotia I can count my own university, which is non-sectarian, three catholic colleges, one Anglican and one Baptist university. In the neighbouring province of New Brunswick there is one Methodist, two or three Catholic as well as a non-sectarian university; so that starting with these I think I could reach a greater number than that mentioned by Dr. Macallum. This became a serious proposition; how could we start to lay out money on the universities from the Government, in a way which, even though hedged around with safeguards, would not be open to the grossest abuse. There is no body of legislators that is free from the influence of votes, or free from the influence of denominational and sectional bodies, and we could not see, and I still fail to see, any way in which a government could subsidize certain universities, when they are not State universities, without the rest feeling that an injustice had been done. That is one point of view. I would like to lay before the Committee another point of view. Suppose you selected three or four universities throughout the country and said: we will subsidize these only, I am assuming now that subsidizing research in universities is a good thing for industrial research. Suppose you did subsidize them, what I want to bring out is that every one of these universities would feel that it ought to be able to take up any problem, whether in rubber, in electricity, or in biology—make it as diverse as you like—and for them to be satisfied or to be effective,

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they would wish to be so organized and so staffed and equipped that they could take care practically of any problem that might arrive, not only in their own neighbourhood, but throughout the country. That meant what? It meant that you would require to have not one large central institute, as we propose, but a central institute at every university. The economic significance of this phase of the matter is so obvious that we felt we could not lay before the Government a proposition which meant establishing as many research institutes as there were universities, and which would result in continuous insistent calls and demands upon the Government. No Research Council could lay such a proposition before any government, it seems to me, without expecting to have it turned down flatly as an extravagant, wasteful and uneconomic proposition.

There is one other phase of the question that I wish to bring out. It is not only that this would not be a proper proposal financially to lay before a government, but from the standpoint of the majority of the Council—I might say almost the entire Council, representing, as I have said, so many university men—it was clear that it would be bad for the universities, and not the best thing for industrial research. If I may be allowed a personal word, I may say that I have spent one-half of my life across the line, having been connected with such universities as Johns Hopkins, Bryn Mawr, Stevens; while I know Columbia University very well, although I was not a member of its staff. I also spent one year at Cambridge in the Cavendish Laboratory, and until I took up my present position as head of Dalhousie University, my life was spent in research, or at all events such time as I could find to devote to it. I feel, therefore, that I know something of the research side of university work, and of what would benefit a university on that side. I feel that to saddle the universities with the problem of carrying on the industrial research of the country would be subversive of the best interests of the universities, and would not be conducive to the best kind of industrial research, for this reason: it has already been brought out, but I think it needs emphasizing—the whole strength of a university's research lies in its perfect freedom, in its being absolutely untrammelled. When you are a university professor laying out a programme for your students to carry out for their doctor's degree, or otherwise, you do not have to answer any objections offered by anybody as to whether it is going to have any value, or whether it is going to make the world any better. These are questions that must be asked in industrial research, but which cannot be asked from your staff or from your students. You simply say there is something to be found out. The untrammelled condition of university life is the very key-note of its success. One hundred and twenty or one hundred and thirty years ago Cavendish, working at science for the mere love of it, and stimulated only by the intellectual satisfaction of learning something new and abstruse, laid the foundation of electrical development as we know it to-day. Follow the course of research further and you come to Faraday, and then Clerk Maxwell to whom we largely owe the modern development of electrical machinery and electric power and light. You need to realize that that work was done without thought of gain, without thought of the possibility of gain. At the time, it seemed perfectly foolish work. From the standpoint of the average man it was hopeless to understand what these scientists were fooling about. Clerk Maxwell worked in pure abstract mathematics, and yet the wireless telegraphy of to-day has been developed from his abstract mathematics. The so-called practical men would laugh at Cavendish, Faraday and Maxwell and would have locked them up because of the apparent futility of the problems they worked at; and yet without them there would have been no such industrial development as we have to-day. Take the work of Pasteur as another example. It was work without any seeming connection with the things that make life worth living or comfortable, and yet in a very short time the results led to the prevention from annihilation of two of the largest industries in France, the silk industry and the vine industry. You cannot estimate these results in

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millions of dollars. My point is this: suppose you were to put a Maxwell, a Faraday, or a Cavendish as a professor in a university having to do industrial research, there would be an insistent and insidious pressure upon the professor to his students to say: I won't put you on this or that sort of research, because you might not get results in five years, and we are supposed to get quick results. I do not say that there would not be exceptions, but you will see the possibilty of insidious pressure being put upon them to take up problems that seem to promise quick results. That means that students would be put on the less important problems, because the fundamental and abstruse one may suggest no application or utilitarian value. One Cavendish, or one Faraday, is worth a whole research laboratory full of mediocre men doing work that they feel must be got under the spur of utilitarianism. That is what impressed me, and that was the final line of argument which brought this Research Council, with practically one exception, to the conclusion that the saddling of the universities with the fostering and conduct of the industrial research of the country would not be for the best, but would really be subversive of the best interests of the universities. Leave them free, leave them untrammelled. Again, it is not for the best interests of industrial research, and the argument for that is contained in what has already been said. In order to get your electric light, your electric energy development you must have had your Faraday, your Cavendish, and your Clerk Maxwell. These results are the natural consequence of the work done by these scientists. In other words, the best interests of industrial research lie in fostering that which is peculiar to all industrial research, pure, abstract fundamental research, that does not tend under the pressure of need to the production of immediate results. There are two separate aims that we have to keep in mind. You want industrial results, and to get them you want men trained to bring about such results. It is the real province of the university to educate and train. Leave them with that; leave them in such a position that they can do that best, and that means leaving them untrammelled. Then you will get your men, and the industries will provide opportunities for all the men the universities can produce. You will then get your results because you have got the men.

There is just one other point that I feel I ought to allude to; that is, the universities' need of support. The Chairman asked a question of Dr. Ruttan, "how are they going to get it?" I am not going to answer it, as Dr. Ruttan has pretty well covered it; but let me insist, if I may, that the universities cannot turn out these men as they are equipped and staffed to-day. They must receive support; they must get assistance, and they must grow and develop. I think it is not invidious for me to say that in scientific research there are only two universities in Canada, Toronto and McGill, that possess the nucleus of a proper research equipment, and it is only a nucleus. I am neither a Toronto man, nor am I a McGill man, and perhaps I can say that of both. They are not equipped to do research work in all branches of pure science. They must be encouraged and assisted. When as a member of the Council I came to the conclusion, as we all did, that one central research institute was all we could ask the Government to establish, we did not forget that in some way the universities must receive assistance. There is a fine opportunity here for doing the very greatest work for the country, but we did not find a way in which the Government could, without tremendous extravagance, help these universities to be put where they ought to be put. Whether the provinces should do it, or individuals, or whether the Federal Government should make grants in aid to universities—for pure research—for real university work, realizing that the strengthening of the research departments in the universities means the strengthening of industrial research—that is another problem.

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STATEMENT BY PROFESSOR J. C. McLENNAN.

The CHAIRMAN: Professor McLennan is here to-day, and I would like him to indicate what his late activities have been.

Prof. J. C. McLENNAN: Two years and a half ago when the question of establishing an Honorary Advisory Council of Scientific and Industrial Research was being discussed, it was my privilege to take an active part in presssing for the institution of such a body. Shortly afterwards, however, it became necessary for me to go to England to take part in the anti-submarine activities, and I have not had the advantage of listening to the discussions of the Council or of taking part in its deliberations in the interval. Nevertheless it has been my good fortune in that interval, to have been closely associated with actual research, and with organizations established for the promotion of research. Perhaps, therefore, I may speak with more effect if I referred to the particular activities with which I have been permitted to be associated, rather than if I gave you an historical résumé of the development of industrial research viewed in its more general aspects.

On looking over the whole economic situation what strikes one as being the most pressing problem at the present time confronting us for solution, is—How are we going to pay our debts? That question strikes with special force every member of the British Commonwealth—how is the appalling debt going to be paid? That is a very practical question.

Available Resources.

When you look over Canada you find you have two great factors available. You have a considerable amount of labour here, and you have intellect—none better in the world. I speak of that from actual contact with it, and from knowledge of it. You have a virility, a freshness of mind, a broad outlook, and a resourcefulness which is not excelled in the whole world to-day. That is my deliberate opinion, based on a consideration of actual results achieved.

But you are not utilizing both of these resources to the limit. Some years ago I had an opportunity of looking into this subject, and I tabulated a list of the distinguished graduates of the universities of this country who had left Canada to go to the United States to occupy academic and scientific positions, and that list was published in one of the Toronto papers, one name after another, and it filled the whole page. There were hundreds of the brightest intellects this country has ever produced who had to go to the United States to earn a livelihood, and they are there still helping to staff the universities and assisting in building up the great industries of that country. You lost, in my judgment, a considerable portion in that way of the best and most vitalized product that this country ever produced. That same movement is going on to-day and at an ever-increasing rate. This is a great leak that ought to be stopped. You have now a magnificent system of public schools, high schools and universities. President Mackenzie said the universities were not what they should be. No, they never will be, but you have to-day, I think, in this country laid a magnificent basis for education. You are also voting, I understand, ten millions of dollars to educate labour in the technical arts. What are you going to do with the products of the educational institutions, and this labour that is technically educated? There you have two great vital factors—wealth-creating factors available. You might turn their energies into agriculture, but I venture to think that by so doing you would not be using these special energies to the best advantage.

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The agricultural progress in this country might be said to be normal now or advancing at a satisfactory rate. Canada has handled the problem of the development of agriculture in a thorough manner. You established agricultural colleges that meet every demand. They are world-renowned. Not only that. You did not centralize there only, but you grasped the problem in its full significance and established the Central Farm at Ottawa, and other farms as well in different parts of the country to deal with the specific problems under local conditions which had to be specially investigated. You centralized, and you decentralized at the same time in order to meet the problem as a whole. There are problems yet to be solved in agriculture such as those connected with the genetics of grain, improvements in the breeds of cattle, methods of dealing with noxious weeds and pests, and all that sort of thing. These will have to be attended to. You have, however, laid the foundation of a system for dealing with them. All you need to do is to supplement from time to time what you have already done, or to extend a system that is well established now.

Then there is the question of fertilizers. The time will come when you will have to supply fertilizers and when you will have to make these synthetically. It has been my privilege to be associated with the Nitrogen Fixation Board in England in the last two years, and I have been able to acquire for you, and to transmit to you, facts and figures regarding the various processes that have been worked out in this connection. In imagination, I can see before me factories established in this country, in suitable localities, where developed water-powers exist, that cannot be used to greater advantage in any other industries utilized for this purpose.

I can see the time coming when these will all be established for supplying fertilizers to the farmers of this country. The provinces will be asked in due course to subsidize them, or to support by direct or indirect subventions, their construction and erection. At present artificial fertilizers are not used to any extent in Canada, but the time will come when vast amounts of such commodities will be required. In the development of methods for producing artificial fertilizers, the projected Central Research Institute can play a leading part.

Mining, too, is looming up in our country. You have a very efficient Mines Branch. It is based on a very fine Geological Survey, and it is doing work of the highest order. The mining industries are flourishing. The one great thing that is required is some means of increasing the national wealth by developing new industries. Agriculture and mining are ready. The labour is ready. The technical knowledge is being produced by the universities. The only outlet for the unabsorbed labour and the technical knowledge that is being produced is in the creation and extension of industry. It is the one great thing that is wanting, and it is for that reason that I have heartily thrown my support in favour of everything that you can do to advance industry. I am not concerned now with what I may call the political side of industry, apart from its being a means of creating national wealth. Industries can be regulated and controlled, but first of all they may first be created. The only way to create national wealth that will be available or can be used, is to create wealth that can be sent out of the country, wealth that is the product of labour, intellectual or manual. That is the wealth of which we can avail ourselves. We can send materials out of the country, or the equivalent of materials. Therefore we must manufacture materials more cheaply than other countries or take advantage of natural resources which other countries do not possess. That means the study of new methods of manufacture and the exploitation of materials found within our borders and not hitherto used. It is not for that reason I have thrown my weight on the side of those supporting the scheme the Advisory Council has put forward for the institution of a Central Research Laboratory.

I think I know that one of the dominant factors in arriving at the conclusion to locate the institution in Ottawa was a political one. You cannot scatter these things

broadcast at the request of every member of Parliament, for the direction of the movement would then become dissipated, weak or ineffectual. You must concentrate for the purpose of efficiency at first. You must always maintain a central control for efficiency. Initially the solution of problems presented for investigation can best be attained by concentrating our activities in one institution, and all factors considered, Ottawa is the best location for it.

The Function of Universities.

Some have proposed that all our industrial research could be done in our Universities. Scientific and industrial research is not however the primary function of universities. It has not at least been their chief function in the past.

Of course in these days of reconstruction, one does modify one's views, but it has not been the business of the universities hitherto, and it is not considered the specific primary business of universities to do industrial research work. Their primary function is to educate and train men and women, and research, though necessary, is in universities merely an aid to education. It is subsidiary. There is no effective teacher in this country, no effective professor who is not doing research work in the course of his work, but it is not his primary business. It is not what he is specifically paid for, and he need not do it frequently unless he wishes to do so. We are liable, therefore, to mar things from a national point of view, if we say that industrial research is to be considered one of the main functions of the universities. You will be apt to mar the educational side of it. I say that because you have laid a good foundation for education in this country. The line of development for our universities is clearly defined. Their chief aim must ever be the production of technically trained men and women prepared for all phases of business life and ready to take part in the creation of national wealth. When you come to the creation of national wealth, research work becomes a business. It is a pure business proposition directed in a certain way without regard to education. Education is preliminary which has been attended to in our universities and colleges. Scientifically educated and technically trained men and women, become, as it were the instruments of research, they become subsidiary. They ought to be used for that purpose, and it is for that reason that our whole aim is directed towards the establishment of a Central Institution as the nucleus of a new system that will permeate and develop the whole country, by utilizing the services of the men and women whom we have trained. In my judgment the programme will not end with a Central Institution. It is a beginning, and a very small beginnings. When I looked over your estimates, I thought it was a lamentably small beginning, and from my point of view it is a totally inadequate beginning. I am amazed to find that the matter has been treated in such a small way by our Advisory Committee, particularly when I think of the large sums of money which you devote, without hesitation, to railways and other similar national agencies. You give millions and millions to railways, and yet when you come to consider a scheme that will some day produce results, that will vivify the whole economic life of Canada, you will readily grasp why a sum of $500,000 or $600,000 is considered insufficient by me for this purpose. It is a mere bagatelle. You may not agree with me gentlemen, but it is true, and you and I may live to see this more clearly before fifteen years are over our heads. By that time we shall be spending far more money than this amount, because I am convinced that the results will be like a geometrical progression. You will be amazed at the results if we can judge from what has happened elsewhere. I would therefore advocate very strongly the establishment of the Central Research Institution under proper direction and administration. When it comes to the question of helping the universities I would follow the principle which we have adopted so far in the activities of our Council. We have in our universities certain professors with particular capabilities and they have particular times during which they can devote

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themselves to certain particular kinds of research work. Help them along sympathetically, and help their universities along sympathetically by means of grants in aid of research. If there are bright students who promise to develop into men of ability and prominence in industry assist them by giving them grants as we do to-day for the conduct of special investigations which they can undertake. To throw the whole question of industrial research into all the universities of this country with diversified views of direction and administration finding expression in the spending of money, would lead, in my opinion, to inefficiency and waste.

Naval Research.

Perhaps now I may refer to what has happened in my own experience in connection with research of another character during the past two years. We were all greatly distressed over the submarine problem, two years ago. Some of us who knew the real difficulty more than others felt that we should like to take part in the activities that were being directed towards the solution of that problem. At that time I came to Ottawa and met some members of Parliament and some members of the Government, and suggested that we should get together and see if we could not do something towards bettering matters. I failed, however, to get any encouragement, and was led to understand that it was not considered that the scientific men of Canada could effectively contribute to the development of the anti-submarine devices and measures in Canada.

Shortly after my visit to Ottawa, however, I was invited to go to England and help in research. On going over I was astounded to find that we were not getting so many submarines as the public generally believed. The Navy was doing magnificent work but it was working by ordinary methods, the only methods available, but these were totally inadequate. Every effort was being put forth to investigate all the subtle little devices that could be developed for chasing and destroying submarines, for seeing them under water, and for detecting them in other ways.

But up to 1917 the main result of all the scientific effort which had been made ended practically with the realization by all that the solution of the submarine menace was probably the most difficult scientific problem that was ever presented to the human race. The arrival of the submarine on the scene practically meant the introduction of a new system of physical science and engineering. We had long search lights for seeing through the air, but we had nothing for seeing through water, and we did not know how far we could hear through water. We did not know how far electro-magnetic effects could be detected in water. All these subjects had to be investigated fundamentally, and they were investigated by many of the ablest scientists in the British Commonwealth.

In the two years which have elapsed since 1917, much progress, however, has been made, and it is now tolerably clear what scientific principles should be applied to overcome the submarine menace. It is now possible to provide scientific means of closing to the passage of submarines, such bodies of water as the Straits of Dover, the Firth of Clyde and the Bristol channel. Even a considerable portion of the North Sea could easily be made impassable to them.

In the development of these measures Canadian scientists have played an important part; Professor Eve, of McGill University, during the past year and a half, acted as Scientific Director at the Admiralty Experimental Station at Harwich, and Professor Boyle, of the University of Alberta, made most important and valuable contributions to the development of probably our most effective method of locating submarines of a chasing boat. Mr. Manson, too, of the Faculty of Applied Science of the University of Toronto, developed a method of guiding ships with safety through mine-fields or through a tortuous and winding channel into a port. Others, such as Mr. Kingdon, of the University of Toronto, made fundamental improvements in

mines and torpedoes. Mr. David Keys carried through investigations on the magnitude of the effects produced by the explosion of charges of various types and sizes under water. Professors Satterly, Burton, Dawes and McTaggart of the University of Toronto, and Mr. John Patterson of the Meteorological Office, Toronto, have assisted in working out methods for extracting helium from the natural gases of Canada. Had the war continued for six months longer than it did we should have had large supplies of the gas available for filling balloons and dirigibles. As the gas is non-explosive and non-inflammable, we should with such air-craft available, have been placed in a position of immense advantage over our enemies.

These illustrations are but typical of many which could be given. The names of many other Canadians who have contributed could also be mentioned, but the ones cited will serve to show that Canadian scientists though not permitted or encouraged at home to utilize their scientific knowledge and capabilities in the direction stated, could when given an opportunity elsewhere demonstrate their ability to carry through researches of the highest order when they were asked to co-operate in the solution of such a great problem as the one presented.

I mention all this to show you that the capabilities of the scientific men of Canada are not by any means a negligible factor. As stated already Canadian men of science are steadily leaving this country. If, however, you utilize their activities they can and will create invaluable wealth for us. The results will be manifest fifty years hence if you lay the foundation of industrial research broadly at this time. This country, fifty years from to-day, will probably have 25,000,000 of a population at the very least. What are you going to do with all these people? If you lay the foundations of industrial research well, and adopt new methods and new processes in our industries, you will create work for them all and that will mean increased production and therefore greatly increased national prosperity.

Hydro-electric Powers.

Perhaps I may be permitted to refer briefly to some of the consequences of the development of hydro-electric powers in Canada. We have, as you know, already developed upwards of 2,305,310 h.p. out of a possible 19,000,000 h.p. in Canada. Judging from the reports to hand it will not be long before an additional 1,000,000 h.p. will be available.

In general, when a power has been developed in the past, the supply of energy rendered available was far in excess of the requirements of the local community for light and mechanical power in manufacturing industries. This state of affairs has led to the erection of extensive and important electro-chemical works which need large blocks of cheap power to meet their technical requirements. Examples of this development are found in the Niagara peninsula, and in the developments on the St. Maurice river in Quebec.

Among the great works in the Niagara district a number are worthy of special mention. The American Cyanamide Company, which also has extensive works at Muscle Shoals, Alabama, has a capacity in its Canadian plant for producing about 64,000 tons of cyanamide per annum. Among its products, in addition to cyanamide, are ammonia, nitric acid, ammonium nitrate, cyanides and argon. It has recently erected works on the New Jersey side of New York harbour for the manufacture of ammonium phosphate, sulphate of ammonia and ammoniacal liquor. The supply of cyanamid for the New York works hitherto has been drawn largely from Canadian works, but the supply will now be supplemented by the product made in Alabama. The phosphate rock used in making ammonium phosphate, I may add, comes from a mine the company recently acquired and is operating in Florida. There is also the Canadian Aloxite Company, whose product is carborundum, and the Acheson Graphite Company, which supplies large graphite electrodes for electro furnaces.

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The Turnbull Electric Metals Company supplies low phosphorus content pig-iron, and the Exelon Company silicon carbide.

The Union Carbide Company has an output of calcium carbide of approximately 125 tons per day, and the Electro-Metals Company manufacture on a large scale ferro-silicon and electric furnace electrodes.

The Riordon Pulp and Paper Company has developed a plant for manufacturing calcium chloride from lime and salt for bleaching purposes, and as a by-product it will soon be in a position to produce caustic soda to the extent of about 35 tons per month.

In the River St. Maurice district we have at Grand Mere Falls, the Laurentide Pulp Mills, producing about 250 tons of paper per day. At Shawinigan the Northern Aluminium Company and the Belgo-Canadian Pulp and Paper Company have very extensive works. The Shawinigan Electric Metals Company is a product of the war, and produces large quantities of magnesium of a guaranteed minimum purity of 99·5 per cent.

The Canadian Carbide Company and the Canadian Electrode Company have large plants as well; but of all the developments which have taken place at Shawinigan the activities of the Canadian Electro Products Company are, from a scientific point of view, probably the most interesting. This company, under the direction of Mr. H. W. Matheson, has developed a process for making acetic acid, acetone, and allied chemicals synthetically from acetylene gas. Its present plant, which is the largest of its kind in the world, was commenced in May, 1916, and the first acetone was turned out in December of the same year. The complete plant consists of twelve buildings, representing an investment of approximately $2,000,000.

With reference to the process itself, this consists of:—

(1) The conversion of acetylene gas to acetaldehyde in the presence of sulphuric acid and a mercury salt. The acetylene gas used in this process is generated in what is probably the largest acetylene gas generating station in existence.

(2) The acetaldehyde is converted to acetic acid by oxidation in the presence of a catalyser.

(3) The glacial acetic acid is decomposed in the presence of a catalyser into acetone. One of the most striking features of the new process is the fact that glacial acetic acid of over 99 per cent strength is obtained from the stills on the first run, thereby assuring quick and economical production of this very essential product. As air is used in this process for oxidizing the acetaldehyde into acetic acid, vast quantities of high purity nitrogen are left over, and at present are allowed to go to waste. With the supplies of calcium carbide available at Shawinigan, we may expect to see this nitrogen used before long for the production of cyanamid, ammonia, and nitric acid, ammonium nitrate and cyanides.

The production of acetic acid and acetone synthetically to which I have referred, is a striking example of how science can add to national wealth. Previous to the war acetone was generally produced by the action of bacteria on grain and other materials suitable for food. By the advance which has been made food materials can be conserved for their more legitimate use and acetone and acetic acid can be made from materials hitherto allowed to go to waste or to remain unused.

The road for producing alcohol in a similar manner is open. The large blocks of hydro-electric power which we shall have available will enable us through the use of electric furnaces or electrolysis to become the producers of large quantities of basic materials, at a cost far below what they can be produced at elsewhere.

We have only made a beginning in the work of developing processes which utilize electric energy, and in a central research institution such as that projected, there will be an opportunity afforded for entering upon this field of scientific and technical activity.

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Helium and other Natural Gases.

I referred briefly a short time ago to the production of helium in Canada, and perhaps I might, with profit, refer to it at greater length. In 1903, it was observed that many of the natural gases of Canada contained a small percentage of helium. In the spring of 1916, it was found that the largest supply of natural gas in Canada, namely, that located at Bow Island, Alberta, contained a little over 0.36 per cent of helium. This is a comparatively small, and apparently insignificant amount, and yet I may tell you that this wonderful gas was so rare and so costly, that at pre-war prices, the value of the supply of it which escaped into the air from the furnaces and stoves of Calgary and other houses on the pipe line, was $50,000,000 per day. By the developments which have taken place, during the past two years, the cost of producing the gas in a pure state, has been reduced roughly 100,000 times. Owing to the advance it became possible to utilize this gas in place of hydrogen in lighter than air aircraft. With the buildings and plants projected by the Admiralty and the authorities of the United States, we should, had the war continued, been able, by June of this year, to produce about 2,000,000 cubic feet of this gas per month for use in our balloons at the front. This would have meant the creation of a great industry in Canada.

Although it will not pay to use the gas for balloons under peace activities, every effort is being made to develop technical uses for this gas, and it is possible that it may yet be required in large quantities for the production of gas-filled lamps, and other articles of commerce.

In a Technical Research Institute, or in institutions allied to it, such technical possibilities can be worked out. Will you encourage your scientific men to take part in this development?

Perhaps you will permit me to refer to one other possible line of development during in the search of helium. It was found that practically all the natural gases issuing from wells situated on the Fraser valley, British Columbia, or from those on the islands of the Gulf of Georgia, consisted of pure nitrogen. Those gases were, of course, non-inflammable, and were considered on that account, by those having to do with them, of no particular value.

In the production of cyanamid and cyanides you know that vast plants are required to extract the nitrogen from the air. If it should turn out that the supply of nitrogen which can be drawn from the wells in the Fraser valley is considerable and permanent, you have in this resource a basis for the production of cyanides and fertilizers on the pacific coast. At such places as Stave lake you have large blocks of electric power either developed or developable In the neighbourhood you have large deposits of crystalline marble and coal as well. The conditions are, therefore, favourable. Of course the land in the Fraser valley is exceedingly fertile now. It will not, however, always remain so and artificial fertilizers will be required in large amounts. In the mean time the lands in the Sacramento valley and those in the northwestern portions of the United States, afford a market for any supplies that may become available. China, too, use large amounts of artificially-made fertilizers.

Before the war, Germany imported large quantities of nitrates from Chili. These, in Germany, were mixed with phosphates and potash and shipped to China where they were given in exchange for various products grown by the Chinese. Among these products were the well-known Soya beans. These when taken to Germany enabled the German industries to make large quantities of oleomargarine, synthetic nitrogenous foods and cattle foods.

Another wealth-producing industry which should be promoted in Canada has to do with the utilization of fish waste. Professor Ruttan of McGill University who has taken a keen interest in this subject, informs me that from 150,000 to 180,000 tons of valuable material of this kind is available and accessible annually. Steps

have been taken to inaugurate the industry. Apparatus has been purchased and is now under way. It is proposed at once to install at Canso, Nova Scotia, two units capable of handling thirty-six tons of fish waste and waste fish per day. Each ton will yield about 600 pounds of concentrated protein food containing 75 per cent to 80 per cent of protein, and about 10 gallons of oil. The new plant will contain appliances for the treatment of the oil, and also for refining and purifying cod liver oil, so that it will be quite equal to the best products of Norway and Scotland.

Here then are wealth producing industries that can possibly be developed with great profit to our country.

Many more possibilities might be referred to, but from what has been stated you will see clearly enough that scientific knowledge, when backed by imagination and supported financially by our people, should be of the greatest service in the upbuilding of our industrial life.

Financial Aid to Research.

You may recall that I stated a short time ago, that the provision Parliament has been asked to make, appeared to me a very meagre one. My reason for making that statement was the knowledge I had of what was being projected elsewhere in research and experiment. As you know, some ten months ago the Admiralty honoured me by asking me to be their scientific adviser and the director of their activities in research and experiment. This department was created among other reasons because it was found in the course of the anti-submarine campaign that many of the devices brought forward for dealing with these could be used as aids to navigation in the neighbourhood of rocky coasts, through ice fields and through fog covered areas. Scientifically it is a crime to-day to run a ship ashore in a fog or in darkness on the coasts of Labrador, Newfoundland and Nova Scotia or British Columbia.

By means of a set of submerged hydrophones, it is possible for a ship to be given accurately its position as far as five hundred miles away. Directional wireless apparatus can be used, and is also being used, for the same purpose. Submerged devices can be provided which will enable a ship, when it comes within fifty miles of such a port as Halifax to be guided in, in safety, even in a fog or darkness, with almost as great accuracy as a tramcar can be directed by a trolley wire.

With hydrophones of the improved type installed on ships, it is possible to pick up for certainty the sound from submerged bells or other sound providing agencies in all weathers as far as 10 or 15 miles.

Devices which enable a chasing ship to detect and locate a submarine can also be used to locate a surface ship or a floating iceberg. Hydrographic work has been greatly stimulated by the possibility of utilizing all the devices.

With a view to perfecting these devices and to providing additional safeguards to navigation, the Admiralty is recommending the British Parliament this year to provide upwards of £1,000,000 for the erection and equipment of a sea experimental station, a signal and wireless school, an engineering laboratory and a Central Research institution designed for the solution of problems of a fundamental nature. Moreover, for the actual conduct of investigations either now being carried on or projected for the current year, it is proposed to ask for an appropriation of upwards of £300,000. From what has been stated you will see that many of the problems to be investigated are of great importance to Canadians. If we can lessen the time of crossing the atlantic through fog-covered areas by one day, per voyage, per ship, you will undoubtedly see that the expenditure on research will soon be paid through a reduction in the cost of transportation and in the increased carrying capacity of a given number of ships. You, I understand, are embarking upon an expenditure of $30,000,000 for the upbuilding of a Canadian Mercantile Marine. Surely for the efficient use of such a

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fleet and for its preservation, it will be worth while to establish a Central Research Laboratory, and possibly also a Sea Laboratory in which Canadian scientists can play their part on behalf or their country by co-operating in working out the solution of problems such as those I have referred to above. //

Scientific and Industrial Research in Great Britain.

In Great Britain and Ireland a Department of Scientific and Industrial Research was established in 1915. Our own Honourary Advisory Scientific and Industrial Research Council was modelled after that organization. At its inception it was given a fund of $5,000,000 to administer. It provides grants in aid of research to graduate students in universities capable of carrying through investigations. It has organized the various trade industries into Research Guilds and these are establishing Research Laboratories under their own direction in which investigations are carried out for the purpose of devising new manufacturing processes or improving old ones. The guilds themselves pay half the cost of the upkeep of these laboratories and the department contributes the other half. In the case of some key industries, the department pays more than half the cost of upkeep. If new processes of manufacture are discovered by the guilds, the benefits pass to those in the guild who contributed to the maintenance of the investigations. Due precautions are taken to protect the interests of the department as well as those of the trade generally.

Boards have also been instituted under the department for dealing with problems of a wider nature than can be directed by the guilds. Among these may be mentioned the Board on Fuel Research. The board has very extensive laboratories, and it is investigating such questions as the economical use of fuel and the utilization of coal and coal tar products.

There is also the Board on Foods which is looking into such questions as the nutritive value of foods, cold storage and food distribution, the production of artificial fats, and other food materials.

There is also a Medical Board which is looking into the question of fatigue as related to workmen and workwomen.

Another board has to do with the problem of housing and is looking into all scientific questions connected with the building of houses, various kinds of timbers and other building materials. It also deals with the most economical methods of heating houses and buildings. Still another board deals with the production of glass for scientific and industrial purposes. It deals besides with the question of design and standardization of scientific instruments.

The Department of Scientific and Industrial Research is not connected organically with the universities. It is directly under a Committee of the Privy Council. Its contact with universities consists merely in making, on application, grants in aid of research to graduate students working under the direction of different professors in various departments of the universities. In addition to its other activities the Department of Scientific and Industrial Research recently assumed the direction and control of the National Physical Laboratory at Teddington. This institution corresponds, in a measure, to the Central Institution it is proposed to establish in Ottawa, and it is similar in its organization and in the character of its work to the Reinchsanstalt in Charlottenburg, Germany, and to the bureau of Standards at Washington. Previous to the war it was largely concerned with the inspection and calibration of scientific and technical instruments such as meters and measuring instruments of all kinds, mechanical and electrical. Manufacturers of all kinds of instruments submitted their wares to the laboratories for inspection and test, and certificates are given stating the accuracy that can be expected to be obtained by the use of these instruments.

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The laboratory also makes tests, both qualitative and quantitative, on the properties of materials submitted for examination.

The laboratory, moreover, is provided with a large marine tank in which the behaviour of boat models can be investigated. This has led to great improvements in ship design. During the war the laboratory was greatly enlarged, and the scope of its activities extended. All kinds of investigations were submitted to it by the Admiralty, the Air Board and the War Office. Through its work great improvements in the design of flying machines were effected, and numerous instruments were designed for use as aids to aerial investigation.

The National Physical Laboratory supplied practically all the gauges required by the Ministry of Munitions for the purpose of making shells, gun-sights and other war mechanisms.

This statement will, perhaps, give you an idea of how National Research is conducted and administered in Britain. The system inaugurated there has now been in operation for practically four years. It has been a great success, and it is largely through its activities that industry in Britain has been reorientated and made ready to face the industrial effort which the present economic situation demands.

The Honourary Council for Scientific and Industrial Research in Canada recommends the establishment of a Central Research Institute as a beginning in working out a scheme for the scientific development of industry in this country. May you look upon its recommendation favourably. If you do the Council will be encouraged to pass on to the consideration of new problems. The economic use of our coal and fuel supplies is a problem which should be investigated at once. The Advisory Council has already instituted a board for looking into the question of briquetting the lignites of Saskatchewan. You have, or have had, a board for dealing with fuel control. A Bill is now before Parliament, it is understood, to establish a board of the Department of the Interior for dealing with coal and the products of the coal industry. All this means duplication and inefficiency. The procedure followed by the British Department of Experiment and Research would seem to be the one which should be followed in this matter. If you support the Advisory Council in its recommendations and encourage it to deal with all phases of scientific and technical problems affecting the economic and industrial life of the country, it will soon become a great and vital force for creating and adding to our national wealth and prosperity.

As a youth I recall being enthralled and filled with wonder by an eminent statesman propounding a new national policy for Canada. In the course of his speech he drew a wonderful picture of forthcoming prosperity for our fair Dominion. Cities were to become hives of industry and chimneys and smokestacks were to be dotted in profusion over the land.

I would fain take you with me to view another picture. I would lead you over a road, through cities beautiful. It is paved with gold and lined with trees and shrubs, crowned with a dense foliage of intellectual and industrial happiness and content. At a turn in the road there sits the master artist science filling in a glorious picture. In one corner I see a beautiful glade terminating in a deep gorge, down which rushes a mountain torrent. The name of the place is Shawinigan. This town is typical. It is scarcely twenty years old. It is beautifully situated amid the Laurentian hills. The streets are well paved and the houses are attractive architecturally. Here there is no smoke to darken the sky. An elaborate town planning scheme has been adopted and all public and private property conform to it. Large sums have been spent on community enterprises, including clubs, auditoriums and schools. As the industries are all highly technical, a minimum amount of unskilled labour is required. Large numbers of technical engineers of all grades are employed and these form the nature of their work, and from the attractive surroundings find their life a very profitable and a happy one.

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When the picture is completed there will be many a scene like this one. Nature has been lavishly kind to Canada. Numerous centres in practically all our provinces, except possibly Prince Edward Island and Saskatchewan, will appear on the canvas. In these provinces the water-powers are negligible. Shall we encourage the master artist to complete the picture? Let us do our part by having the Central Research Institute inserted in the foreground. //

Mr. SHEARD: I think that the figures which Professor McLennan has given us more or less in confidence would be an inspiration to the country. I think they are particularly valuable, and I feel that this committee ought to make use of them, not only in the House of Commons but in a concertive effort to get the necessary funds from the Government for this work which is regarded by a great many people as somewhat mystic. I think that what he has told us will be of great assistance.

Mr. MCGIBBON: Not only that, but I think they would be useful in convincing some members of the Government.

Mr. SHEARD: We have got to show how far the British Government have advanced ahead of us in such endeavours, and it is just such concrete facts as Professor McLennan has submitted that will assist us in bringing about the desired reformation in this country.

Dr. MCLENNAN: An important thing to remember is that in England they were apathetic. At the beginning of the war no public man would have dreamed of coming forward with a programme such as is now proposed. I must confess that as I listened to Sir Eric Geddes I was amazed.

Mr. MCGIBBON: I heartily endorse Mr. Sheard's suggestion.

Mr. SHEARD: If we could also get from Professor McLennan an abstract of some of those great results which he has described, I think it would be most valuable.

The CHAIRMAN: Yes, I think we must show examples of concrete results in order to convince.

Mr. SHEARD: I think the statement of Professor McLennan is an inspiration, and I have given some attention to the scientific problem. If we can press home those points to those who have never dreamed of such results as have been achieved, I think it will be of great benefit.

Professor R. D. MCLAURIN: I was particularly interested in part of the suggestions made by Dr. McLennan. That is the application of science to the development of our natural resources. That is one of the most vital problems which is facing Canada at the present time. In view of our tremendous national debt ways and means must be devised whereby our natural resources may be utilized to the best advantages. Last year we imported into Canada coal to the value of $71,000,000, and almost 98 per cent of our oil at a cost of $30,000,000, and our iron ore and iron products in 1917 to the extent of $187,000,000, making a total of $288,000,000 for imports for these raw materials. We know that the utilization by the best scientific methods of the resources of nations is the only way whereby a nation can be placed in an economically safe position. We have in Canada tremendous resources in these basic materials, and these materials form the basis for essential national industries, and it seems to me vital that these materials should be produced in large quantities, and in order to get a comprehensive idea of the national significance of basic materials, it is necessary to compare the resources of the various nations, and the methods employed by the nations in utilizing those resources in the most economic way. Take the national significance of coal. We know that England built up her entire foreign trade of coal export. By producing cheap coal Great Britain was able to bring in products at a low cost, and consequently that affected every industry in Great Britain.

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We know to day that Great Britain is facing a crisis in the coal industry, for the reason that the cost of production of coal is high. The cost of production, according to the *Economist*, of coal in Great Britain is $7 for a long ton at the mouth of the mines in Wales and Newcastle. In the United States the cost of production is $2.75 for a short ton, consequently the competition is very adverse to Great Britain. Now in order to lower the cost of production a committee, or a commission, has been appointed to investigate every phase of the coal industry in Great Britain, including the production and management of the mines, and also in regard to the labour situation. At the present time Great Britain is producing just about enough coal for their own needs and it is necessary for ships to go out in ballast. That, of course, is a very serious condition The decrease in production has been about twenty per cent, which amounted to practically the amount of export. The decrease in export was 56·7 per cent, so that that is a very large reduction. The United States during the war increased their foreign trade in Europe to the extent of 243 per cent and in South America to 350 per cent; so that the United States is entering into a market which Great Britain formerly had to a very large extent. In Canada we have a very large supply of coal. The United States possesses 51 per cent of the total world's supply of coal, and in Canada we have only 17½ per cent of the total world's supply, standing second. So that our strategic position is very marked in regard to coal. Most of the coal is in Western Canada. We have about 12 per cent of the total world's supply of coal in Western Canada. The immediate problem for us is to devise means whereby our coal may be used most economically and marketed to the best advantage, and at the present time the Government has made a very important move in preparing to establish a briquetting plant for the treatment of low grade lignite. There seems to be more or less of a misunderstanding regarding the value of western coal. When lignites are spoken of the general opinion is that the lignites referred to are the lowest grade coal. The coals in Saskatchewan and Manitoba are probably the lowest grades of coal. There that low grade coal, simply because the moisture content is high, breaks down very rapidly when exposed to weather conditions. On the other hand, we have enormous deposits of high grade bituminous coal and semi-anthracite coal. In addition to the briquetting problem, the object of this plant was to produce a fuel which would be the equivalent in heating units to anthracite. That is one phase of the problem, and a very important phase. It is important from another standpoint. From an industrial standpoint it is extremely important because we will know how to utilize the by-products, both from the tars and from the gas and ammonia which are obtained from the distillation of coal. On the other hand, the economic utilization, or burning of the bituminous coal has not been dealt with to any appreciable extent. It seems to be extremely important that when we know that at least 25 per cent of our western coal goes up in the smoke stack owing to the fact that the coal has a high volatile content, and that the furnaces on the market are not designed to burn a high volatile content, it seems to me that much research work can be done along the line of combustion. That is really a national question, because all fuel must be burned no matter in what form, whether liquid, solid or gaseous, I might say that in addition to studying the conditions under which combustion can be perfected, it will be necessary to modify the designs of furnaces. The first thing to do is to endeavour to modify the existing furnaces, or if it is possible with the equipment already available, to modify the furnaces in such a way that the fuel may be better utilized where a higher percentage of the volatile matter of the coal can be oxidized. If that is not possible, the only other alternative is to devise other furnaces.

Another phase of the fuel problem in western Canada is that a very large number of companies are operated, and they are operating for a very short period during the year. That creates conditions, which, from a labour standpoint, are difficult to control, and it also makes the fuel produced at a higher cost than it should be, owing

to the fact that the plants are only operated for part of the season. It seems to me that considerable could be done by organizing the producing coal industries in such a way that coal can be produced at a lower cost, and also by better methods of combustion. I feel pretty well satisfied that there is no necessity for importing anthracite coal into western Canada at all. It is a matter of getting coal which is more suitable on the market at the right time. Last year a great deal of coal was stored, and there was some difficulty in not knowing how to handle that coal when put on the market, in not providing proper facilities for marketing. If the proper coal were put on the market during the summer, a large part of that difficulty would be removed, because there are coals which can be put on the market in western Canada during the summer, and which do not slack. I have kept certain coals, pea coal, for example, in sacks for three years, and there was no observable change. That is one of the problems we have in the west, the economic utilization of the tremendous quantity of fuel that we have. In Germany, of course, the national significance of coal was worked out in a different way. In Great Britain the coal was exported, and Great Britain built up her foreign trade on her coal export. In Germany, the distillation of coal formed the corner stone of her economic and industrial system. The coal tar products were obtained for producing dyes and for pharmaceutical and photographic purposes. Germany gained control in the world's markets for products from the distillation of coal. Gas was used in the metallurgical industries, and the ammonia was used for fertilizing purposes. Germany gained control of the world's markets in these materials, and at the same time prevented other countries from establishing this basic national industry. Consequently they were not in a position—they did not have the personnel nor the equipment to produce these materials, and consequently they were unprepared for war, because these same compounds were the compounds from which explosives were made. That was the national significance of the utilization of coal in Germany. The carbonizing process which would be worked out on our coals is fundamental from that standpoint. It seems to me that we should combine the two, that is, the efficient utilization of the coal in addition to the carbonizing process.

I would like to mention a few facts in regard to the world's actual supply, and also in regard to production, comparing the production of coal in Great Britain and the United States. In 1870, Great Britain produced 124,000,000 tons of coal. In 1918 she produced 227,000,000 tons, or slightly less than double. The United States in 1870 produced 33,000,000 tons of coal, and in 1918, 685,000,000 tons, or about 23 times this much. Since the United States possesses 51 per cent of the world's supply of coal, you will see that it is placed in a very formidable position. In 1870, the rest of the world, outside of the United States and Great Britain produced 80,000,000 tons, and in 1918, 500,000,000 tons. That means that the United States produced last year more coal than all the other countries in the world outside of Great Britain. In regard to the total supply of coal in the world, it is difficult to make any particular estimate. It has been estimated at 800 billion metric tons, and we have in Canada 17½ per cent of the total world's supply, of which 12 per cent is in Western Canada. The strategic position which this country occupies in regard to coal is therefore apparent.

Another subject in which I am interested is the national significance of oil. Perhaps the national significance of oil can best be illustrated by the fact that the British Government have actually gone into the oil business as it were. They are endeavouring through a Government Department to get control of the petroleum resources in various foreign countries for the reason that during the war the United States supplied Great Britain with 80 per cent of petroleum products, and Great Britain does not wish to remain in that dependent position."

And through the government, and being financed by the government, the British Government are endeavouring to get control of foreign fields as regards petroleum.

[Professor R. D. McLaurin.]

Now the United States up to the present time have supplied 65 per cent of the total world's supply of petroleum and about 1917 a commission was appointed to inquire into the potential oil resources of the United States, and the report was that it was probable that the oil resources of the United States would be exhausted in 27 years. Last year the United States imported from Mexico 38,000,000 barrels of oil, and utilized 28,000,000 barrels of their reserve. In other words the United States last year was an importing nation, and a recent report from Mr. David White, of the Geological Survey Department, pointed that out to the American Government, and advised American capital interested in oil to go into foreign territory. At the present time that has not been necessary, because the United States was the greatest oil-producing country in the world, and all their capital was invested in the United States. He points out that Great Britain is endeavouring to get control of the oil resources in foreign countries. If she is successful in completing that, then it is only a matter of time until the United States will be importing oil from Great Britain, and this recommendation has pointed out the necessity for American capital to go into foreign territory. In Canada, Dr. Bosworth, the British Geologist, who is now the geologist for the Imperial Oil Company, in 1915 published a preliminary report in the Petroleum World, February number, of his investigations in the Peace and Athabaska districts, and he made the statement that the asphalted outcrops and oil seepages in the Mackenzie basin were greater than in all the other countries in the world combined. He made an estimate also of the area. He said the area was probably 10,000 square miles, and that if the oil contained in the sand was uniform, there was sufficient oil in the tar sands of the Mackenzie basin to supply the world's consumption, at its present rate, for two thousand years. That is a very big statement to make, and it appeared in that report. The point is that the surface indications for oil are greater in Northern Alberta than anywhere else in the world, and since we import into Canada practically all our oil, last year at a cost of $30,000,000, it seems imperative that, with these potential reserves, immediate steps should be taken to see that these resources are developed.

Now, as regard iron ore, the national significance of iron ore can best be illustrated by what has happened in regard to the settling of the peace terms. The Monet Oil Fields are probably the greatest iron deposits in the world, covering 463 square miles. Great Britain is also faced at the present time with the proposition of reorganizing the iron and steel industry. During the war the United States made enormous profits in the iron and steel industries, and they have utilized those profits in extending and improving the industries, whereas in Great Britain and Ireland the iron and steel products were all used for war purposes, and a large amount of the profits were utilized also in the form of taxation. Consequently the iron and steel industries in Great Britain have not been extended to the same extent as they have been in the United States. As a matter of fact, certain iron and steel products can be produced in the United States at a lower cost at the present time than in Great Britain. That has necessitated an investigation into the iron and steel industry, for the purpose of getting the industry re-organized, so that they will be able to compete with the United States. In Canada we import 95·8 of our iron ore and iron products, and we have large deposits of iron, and it would seem absolutely essential that immediate steps be taken to develop the iron and steel industry in this country, as it is one of fundamental and basic national industries.

Professor MacLennan mentioned the matter of fertilizers. I would just like to say a word about fertilizers. In Canada, the only national industry, we might say, is agriculture. The Canadian people recognize that. Everyone recognizes the importance of agriculture. We should have the same thing in science. It is necessary to create a national industrial consciousness, because we have that in agriculture, but we have not that same thing as regards the application of science to the development of

our mineral products. I made a calculation recently of the quantity of phosphorus potash and nitrogen that is shipped out of western Canada when we export 100,000,000 bushels of wheat. I got the prices in Toronto of the cost of these constituents per ton delivered at Saskatoon. I worked out the quantity of nitrogen phosphorus and potash that were shipped out, and the cost to bring those three constituents from Toronto to Saskatoon, and the cost was $66,000,000. I also made an estimate of the quantity of potash and nitrogen in the straw, resulting from a crop of 100,000,000 bushels, taking the average yield of straw at one ton per acre, and the average yield of wheat at 15 bushels to the acre, and it cost practically the same amount, $66,000,000, making a total of $132,000,000 to bring the quantity of fertilizers from Toronto to Saskatoon that were shipped out in 100,000,000 bushels of wheat, and the quantity which was practically all destroyed when the straw was burned in Western Canada. Now it is only a matter of time until it will be necessary to replace in the soil that quantity of fertilizer and we should be looking forward to the time when the necessary constituents will be available. Part of that can be overcome by encouraging the milling industry so as to develop to a much larger extent than at present time the export of flour. Under that system a large part of the by-product will be retained in the country and used in the fattening of stock, thereby encouraging the live stock industry and a considerable part of these fertilizing constituents would thereby be retained. Now another phase of that question: We are endeavouring also to utilize the straw by carbonizing it and utilizing the gas for domestic purposes, that is for heating, lighting and cooking, and in the carbonized residue a large percentage of these constituents remain, especially potash and phosphorus. If we are to be successful in working out processes in carbonizing the straw a great deal of these difficulties would be overcome.

The CHAIRMAN: Just before leaving straw, your calculation was that the straw from which you mentioned a profit was the straw from a hundred million bushels.

Professor MCLAURIN: Yes.

Mr. MCGIBBON: Did the cost of the fertilizer you mentioned include freight from Toronto?

Professor MCLAURIN: The cost of the fertilizer, and of course the freight is $1,500,000 or $2,000,000.

Mr. MCGIBBON: And that would amount to about $1.13 a bushel.

Professor MCLAURIN: Yes, about that.

Mr. MCGIBBON: And that is thrown away at the present time.

Professor MCLAURIN: Take oil, coal and iron, that we are importing a tremendous quantity of, over 50 per cent of our coal, into a country which contains 17½ per cent of the coal. We know there is no coal in Quebec or Ontario, but if we are exporting it is possible to develop an export trade in the west with the Western States, Washington, Idaho, and Montana. We have coal also at the Atlantic and at the Pacific Coasts and in the Hudson bay. We are closer to the European markets than the other countries. It seems to me that we should be able to develop a large export trade in this country and even if we are importing into Ontario and Quebec it will be offset by the other exports. We import 85 per cent of coal and iron and practically all the oil. These materials are the bases of a great national industry and it seems to me that the time has arrived when we should do everything to stimulate the production of these articles at very little cost.

Mr. THOMPSON: I think you have put your finger on the spot when you say that we should do all we can to develop an export trade with Western Canada. That is what we want to do; we know the coal is there but how are we to bring about this export trade?

Professor McLaurin: We can organize the industry on a better basis than it is now and get the cost of production down, and we can do the very same thing that is done in business, send the men to get the market. A man in business with certain products in his warehouse sends men out to sell them.

Mr. Thompson: You could not sell that coal here in the East.

Professor McLaurin: Sell it in Washington and other western states.

Mr. Thompson: But it is only in the states where they do not produce coal, that is the only market we have.

Professor McLaurin: We can easily sell it there as far as Alberta is concerned.

Mr. Thompson: I understand, Professor, you are speaking of the coal underlying the plains.

Professor McLaurin: We have coal on the Pacific Coast and on the Atlantic as well, that is for export we can develop the coal areas on the Pacific and on the Atlantic Coasts for the foreign market, but for the United States market we can utilize the coals of Alberta.

Mr. Thompson: Well, it is the coal of Alberta that I am thinking of particularly; how can we develop trade between Alberta and the States adjacent to that province? Is there anything we can do to develop that trade?

Professor McLaurin: Yes, two things, as I have said; that is organize the industry in such a way as to produce coal cheaper than it is produced now. We all know that the industry is very badly organized and we also know there is no coal in those states, and in addition to that better methods of utilizing this coal.

Mr. Tweedie: We have all these resources and from the purely financial and economic point of view questions of transportation, of production and of market may enter into it, but from the scientific research point of view to what other uses can we put the material which we have in our country than those to which they are put to the present time? What by-products can we get from our coal that will make it a really national asset, other than the producing of power and heat. In Alberta they have a by-product, coke, in which they utilize the coal to a very large extent.

Professor McLaurin: Certainly.

Mr. Tweedie: What scientific principles can we adopt to produce an asset from the straw which is burned on the prairies every year after the harvest? It is a work for the provinces to solve.

Professor McLaurin: As far as the economic side of it is concerned.

Mr. Tweedie: I think that the salvation is for the farmers to work scientifically and to save these natural products.

Professor McLaurin: That is what we are endeavouring to do. The combustion for them is most important as we know there is over 25 per cent of the coal which is now wasted owing to insufficient combustion. That is a matter for study to determine a method by which it can be burned economically and the heat utilized.

Mr. Tweedie: Just how closely do you think that the industrial and scientific are related from a purely economic point of view? I gather from what has been said that scientific research is very valuable by reason of the fact that often results are obtained which are perhaps not thought of at the inception of the work. Now take our resources in this country, what is your theory in regard to the actual relation between our actual resources and scientific research? Do you carry out your scientific research and produce results which are perhaps not anticipated or do you start from the results and work backward from that?

It would be foolish for scientific men to neglect resources. They go on working from pure love of following up. Here is his knowledge, and where he can, he

switches that in, and in the doing of that, other ideas come in. It is a stream of thought and of activity that is necessary now. Speaking of markets, do not forget China when you are talking of the West. There is an enormous population there, and we have resources in Canada that would find an outlet in China. The Japanese know that. They are bending every effort to exploit their resources in China, but they have not got such resources as we have. In regard to coal, we know what Germany has done in the way of dye stuffs and pharmaceutical and photographic preparations. We can do that in Western Canada if we have a market, and there is a market in China. That means that we shall have to get our whole Consular system going as well. We shall have to alter our whole outlook. This is the beginning of a national movement, if I judge correctly. If you have a group of men in your central organization, they will furnish suggestions and do a great deal to stimulate the growth of these industries.

Mr. TWEEDIE: In other words, the scientific research which we are considering, will produce results and then it will go one step further and apply these results to the commercial activities of the country?

Professor MACLENNAN: Yes.

The Committee adjourned.

FRIDAY, May 23, 1919.

The Committee met at 10.30 a.m., Mr. Cronyn, Chairman, presiding.

The CHAIRMAN: In response to the request of Mr. Nickle, Professor Clark of Queen's University is here this morning.

Professor CLARK called.

The CHAIRMAN: The usual course is for those who appear before the Committee to make a statement along such lines as they desire and questions are asked. If you prefer to make a statement and answer questions later I think the Committee will have regard to your desire.

Prof. CLARK: I think I would prefer to make a statement first. Mr. Chairman and Gentlemen, I wish to express my gratification at being asked to present my views on the important subject of the development of scientific research in Canada. I can hardly claim complete knowledge on the subject, but such information as I have I would like in response to your invitation to give to the committee. In the short time in which I have known I was to be here I have put down a few ideas I would like to present and crave the indulgence of the committee if I present matters that may have been presented very much more ably than I can give them. Not many Canadian manufacturers yet realize what is being accomplished by the application of scientific research to industry. A paper by Professor Fields on Industrial Research in the United States which appeared in the March number of the University of Toronto Monthly gives a very convincing description of what has already been accomplished in the United States. The largest industries like the Dupont Company. the General Electric, the Western Electric and the Eastman Kodak Company and a number of others are spending very large sums of money annually upon research and getting a very good return for their expenditure and it is the opinion of men in charge of these laboratories that this phase of industrial life is sure to grow. Here in Canada the attempts

to develop industry through scientific research are not so numerous or not so great with one or two exceptions in the various manufactures, the chemical manufactories, particularly the paint factories, rubber and sugar refineries, in the electrical work and other great manufacturing plants. These firms are employing research men, not as a rule the best trained men, but men are being employed for the carrying forward of this work. Now it seems to be the opinion of every one in touch with the situation in Canada and in other countries, particularly in the United States which I know somewhat better than I do other countries, the opinion seems to be growing that if we are to keep pace with the development in other great producing countries we must make effort to develop scientific research in this country and carry it more and more into the industries. A great many people at the present time are concerned in the solution of the problem, largely through the efforts of the Honorary Council which has been bringing the matter before the country so continuously, during the last two years, but it does not seem that the people of the country as a whole have grasped the importance of this movement. Now the fact that this Parliamentary Committee is sitting to determine just what course should be pursued is in my opinion the most hopeful sign in the whole situation as regards the development of scientific research, indicating that something is to be done. And I have talked with the directors of some of the largest research laboratories on this continent; I have been impressed with the uniformity with which they all say the great problem is the production of trained men; they harp on that continuously that there is a dearth of properly equipped and trained men, and all these men who are in charge of this work seem to feel that this is the great problem of the immediate future, the securing of these men, and I find that they are intensely interested in the question of establishing a greater source of supply.

Last week I visited the Bureau of Standards at Washington, the research laboratory of the General Electric Company and the research laboratory of the Western Electric Company in New York. In each case I spent considerable time with the director of the laboratory and we discussed this point—where we were to go to get the supply of men which is absolutely necessary for the carrying forward of this great movement. I am glad to say that over there they are intensely interested in what is going on here and are waiting to see just what the outcome will be. If I may quote briefly from an address by Dr. F. B. Jewett of the Western Electric Company delivered before the Royal Canadian Institute in February.

(Reads):

> "Two courses only appear promising:
>
> 1. The establishment of a limited number of large research laboratories which are endowed either by the State or other private or corporate munificence; or
>
> 2. The stimulation of scientific research in a more diverse fashion through the universities and higher educational institutions.
>
> The success of the first plan on a scale adequate to the needs of the State would appear to involve a concentration at the limited number of research institutions of practically all the country's leading scientists qualified to engage in fundamental research or in the proper instruction of men for the industrial field. This would tend largely to deprive the colleges and universities of the services of all the men with a research trend of mind and leave them with an atmosphere wholly pedagogical in character. Far more serious than the mere absence from the university faculty of the advanced thinkers, would be the fact that such absence would bring about a condition in which there was nothing to stimulate properly qualified young men to take up scientific research as a life pursuit.
>
> Considerations such as these tend toward an adoption of the second alternative. Such a plan does not and should not contemplate making every so-called

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university or college a centre of research. Financial and legislative assistance of whatever form, should be reserved for those institutions which are equipped or can be equipped with the necessary men and facilities for carrying on properly the work of research and training."

I find that the men in the other laboratories in the United States take not exactly the same view as Dr. Jewett, but a similar view, that the source of supply of trained men is the thing that the nation must look at in the near future. I find myself in agreement with these men that the pressing need is the securing of a steady stream of trained men who shall become the research workers of the future. We have a limited number of scientific men in Canada, many of them in the universities where there is already much equipment. I believe that they can do the most good where they are. If they can be encouraged to devote their energies to research, and have associated with them students who would become infused with the research spirit, more could be done for the country than by the establishment of a dozen research institutes, for our hope lies in the scientist yet to be discovered. Who knows where a Faraday, a Relini, a Ramsay, a Rutherford, a Curié, a Pictut, a Cailletet may appear? The potential scientist must be brought out. Of course, I am speaking as a university man for the utilization of the existing university laboratories, for in them I feel lies the solution of the problem in Canada. May I mention a few simple discoveries that have emanated from university laboratories. I could explain the list at very great length, but I shall deal only with a few of the most obvious and best known. In 1895 Prof. Roentgen was conducting experiments in his laboratory at Wurtzburg with a glass tube from which the air had been pumped out. He passed an electric spark through the tube which was completely covered with black paper, and he noticed that a nearby paper coated with platin ocyanide of barium glowed brightly. He traced the phenomenon back to the interior of the tube and found he was dealing with a hitherto unknown form of radiation. Not knowing what it was, he called it X-rays. He soon found that some bodies allowed the rays to pass through well, others not so well, and also that these rays affected the photographic plate so that shadows cast by dense bodies could be seen and photographed. What has developed from this discovery? In the hands of research workers all over the world, the tubes and accessory apparatus have been developed until every medical practitioner is equipped with the X-ray outfit and the service it has rendered in the war is incalculable. Bullets, fragments of shell, or any other foreign bodies are seen and removed, fractures of bones are seen easily; tuberculosis of the lungs even when not far advanced is easily seen, and various other diseases make their own peculiar shadows on the plate. Each year sees a new advance, and these are coming more and more through the efforts of research workers. Last week, while at the General Electric Company's laboratory I saw some of the recent developments of X-ray research in the hands of the expert, Dr. Couledge. He has reduced the size of the case from 8 inches or 9 inches in diameter to 2 inches or 3 inches and attached a small transformer. It does not require the tremendous equipment that the doctors have had to supply themselves with during the last ten years.

Then the wireless telegraph and telephone are the outcome of some experiments by Hertz, at the University of Bonn in Germany. Maxwell, Britain's peerless scientist, had foreseen something of the kind, but, while his views remained in obscurity in England, they were investigated in Germany. Hertz found that there were real waves of electrical origin. He found out how to produce them, how to receive them, and found out many of their properties. His work laid the foundation, and step by step the apparatus and methods of use have developed until now we may telegraph and even telephone from Ottawa to London, and probably before long, to Australia. But this great advance has come only through the painstaking efforts of a great number of men in laboratories all over the world. The time is not far off when you may call up a friend anywhere in the world and hold conversation with him.

[Professor Clark.]

The thermos bottle or Dewar flask, as it is called in the laboratory, was invented by Sir James Dewar of the Royal Institution at London to hold his liquid air and liquid hydrogen. Necessity was the mother of this invention, as of many others. A recent writer has said, "if a thing can really be conceived, it can be made". This is the attitude of the modern scientific research worker. Sir James needed a heat tight bottle and made it, a marvel of simplicity, but how it adds to our comfort in winter or in summer. You may be interested to know that in England they are being manufactured now of steel instead of glass but are not likely to supersede them.

You ride on the street cars and never think of the motors under the car with their intricate mechanism or of the great dynamos at the central power stations. Without the work of Faraday, again of the Royal Institution, working in his little laboratory in the cellar, no power-mission would be possible. Of course, some one else would have discovered what Faraday did, but he would have been a lonely experimenter working away for the pure love of the work. Without this lonely worker, modern electrical science would be an impossibility. The telephone was a result of the same initial discovery of Faraday.

We have all heard a great deal about optical glass since the war began. Optical glass is a fine variety of glass suitable for optical instruments, like telescopes, microscopes, field glasses, range finders and the like. Why are we so dependent on Germany for fine optical instruments? Because Prof. Abbe of the University of Jena made an exhausted study of glass manufacture, and with Schott discovered a long series of new glasses with such properties that new lenses could be made which had been regarded as impossible. The Prussian Government subsidized the work, and the great works at Jena became famous and supplied the whole world. Of course, through prodigious effort we have now discovered how to do the same things, and can do just as well as the Germans in this as in many other things. Lord Kelvin of Glasgow was knighted for his work in connection with the Atlantic cable. The first cables were pierced by ignorant misuse, and until Kelvin brought his laboratory experimenting to bear on the problem, the submarine cable was doomed to failure. He found out the trouble, and remedied it.

You have heard a great deal about fertilizers and the great nitrate deposits of Chili, a great deal about the need for nitric acid for making explosives, as well as fertilizers. To make these a supply of nitrogen is necessary and the great source of supply is the atmospheric air. Some of the best processes for extracting nitrogen from the air require the use of extreme cold, so far below zero that air becomes a liquid like water. Then the nitrogen can be separated from the oxygen. Liquid air was for many years an interesting curiosity of the laboratory. Who had heard of the cost of helium until very recently? Had we gone on a few months more every one would have known about it. Helium is a very rare gas nearly as good as hydrogen for filling balloons, but unlike hydrogen it is not inflammable. Fire is a great and ever present danger with hydrogen-filled balloons. The United States Government, upon earnest solicitation of the British Government, undertook to find a helium supply. This was discovered in certain natural gas wells, of which we have some in Ontario and the gas was being produced at the rate of thousands of cubic feet per day when the Armistice was signed. I am told it was on the docks in cylinders ready to ship at the time of the Armistice. Helium was discovered by astronomers in the sun's atmosphere long before it was known on the earth. It was discovered by Sir William Ramsay as a component of the atmosphere of the earth, and it has been sought for diligently for years.

Upon questioning one of the men in Washington I found that helium existed in some of those gases to as high a percentage as one per cent, so that there is a very large supply of helium when we know how to get it.

The nitrogen-filled lamp was a result of scientific investigation by Langmuir of the General Electric Company, at Schenectady. It has been superseded by the argon-filled lamp. Who a few years ago ever heard of argon? It is another of those rare

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gases discovered by Ramsay in the atmosphere of the earth. It is inert and odourless, tasteless, less everything but existence, therefore useful in the lamp where it cannot act upon the filament. I might go on almost indefinitely, but I forbear. Who shall say that the recent work at Cambridge and Manchester, McGill and Toronto, on the structure of the atom and kindred problems will not result in the most revolutionary industrial application? It it almost certain that we shall see all of this new knowledge applied to processes and results now undreamed of except by a few. It is probable, indeed certain, that the more we expand our scientific vision, the more hope there is for us as a nation, industrially and otherwise. It is research or obscurity. Our resources are great, but we must do more than use them. We must find new ones, new methods, new products and new application. To do this we need a stream of workers, far greater than we at present can hope to have. If we go in for this research—and we surely must do so—we should not be content with scratching the surface with imitations. We should begin by stablishing a system of training workers and create a scientific atmosphere as it has never been done in any country. This country is rich, a few millions spent on research will yield untold millions and prestige beyond our dreams. Wherever there is a laboratory equipped with men of the right type, make use of it. Whenever an institution or an individual is willing to make the financial or personal expenditure of money or time, he should be encouraged to do so."

At Queens University we have already begun to work out a plan which we hope will lead towards this desired object, largely through the influence of Mr. Nickle, one of our trustees, who has, from the first of the agitation for research, been kindly interested in this development. Largely through his influence we have been enabled to establish a Research Department, and we are encouraging our men to engage in research. We furnish the equipment so far as we can, and assistance on a modest scale, and are hoping soon to relieve professors of their routine duties, so that they may engage in the research. We are establishing courses for the training of research workers which are attracting the men, and they can be attracted by work which is actually in progress as they can be attracted in no other way. I have been struck by the intense keen interest with which our students observe the small amount of research that is going on at Queens, and how interested they are as they come up to the first, second and third years of their course to know more about it, and they are asking questions, whether they cannot get into this kind of work, so that I am firmly convinced that the way to attract these men into the research field is for them to see research going on around them, and to feel the influence of the research spirit through the universities. One large smelting company has already made an arrangement with the universities whereby its laboratories are utilized for their research problems. I regard this as a temporary measure, but it is one of the things we are trying to do to link up the industries with the university, and let them take advantage of the university facilities. We have recently appointed on our staff a mineralogist with long training in the laboratory at Washington, and during the war his time was given almost entirely to problems in glass manufacture. He was with the Pittsburg Glass Company working on problems in regard to optical glass. We are trying to equip a laboratory for him, so that he can go on solving these problems of glass manufacture. Our efforts have met with some success, but they are on too small a scale. They are not meeting the present need of the company sufficiently. During the war a similar plan was carried out in Great Britain. I may quote briefly from the report of the Privy Council for scientific and industrial research of Great Britain 1915-16, as follows:—

> "If the universities get their full share of the new work in pure science they will do much, but they can do more. They can also with their existing organizations assist smaller firms and less important industries to solve the problems immediately in front of them, and they can, no doubt, attack those fundamental problems of research in applied science which are not too complex

[Professor Clark.]

or too extended in their nature. The chemical constitution of the stilbene dyes was, for instance, worked out at the University of Leeds, research into the nature and constitution of cellulose fibres has recently been suggested for the school of technology at Manchester; the de-gumming of silk is being investigated at the Imperial college of science and technology; the design of steam nozzles for turbines has been the subject of research both at the Royal Technical College, Glasgow, and at the University of Manchester."

What was being done, and what is being attempted on a small scale at Queens, can be duplicated at other university laboratories if the arrangement can be made. The things to be accomplished under such a plan are these: the solution of such problems as are not well handled in industrial laboratories, the training of the future workers and the gradual education of the whole people to the importance and value of research through close contact with it and its results, and in this way the interests of university laboratories can be linked up so that these industries can gradually become self-supporting in their research effort, and finally stand on their feet. At the present time in the United States the research movements have gone further than in Canada. The universities there seem to be getting weaker in their scientific faculties, so that there are very few first-class men left there to do the necessary training. All sorts of remedies are being proposed. For example, the distribution of federal funds for certain institutions for research and development. That has been proposed in a Bill before the American Congress known as the Smith-Howard Bill, the fate of which is more or less uncertain. It will probably come up before Congress, which is about to convene but no one dares to predict what the outcome will be. Second, the linking up of the universities with the industries, so that each may supplement the other. Dr. Whitney of the General Electric laboratory, told me that this proposal was being considered. In Schenectady there is a college known as Union College with an Engineering Department, and the proposal is that the Engineering Department of Union College and the research laboratory at Schenectady of the General Electric Company shall co-operate so that each shall furnish some for the other. That is to say, that the college laboratory may have the benefit of the General Electric Company's laboratories, while the General Electric people may have the benefit of the men at Union College.

Mr. SHEARD: How many students have they at Union College?

Professor CLARK: I cannot tell you exactly; I think in the neighbourhood of 500 or 600. In the Engineering Faculty which is the strongest, I should say there were between 300 and 400; but that is not from definite information.

Mr. SHEARD: My reason for asking is that I wish to know whether the work purposes to instruct employees or to train scientific men.

Professor CLARK: As I understand it, the movement is for a two-fold purpose; to enable the General Electric Company's laboratory to have men trained at Union College, and then they would get them later. From the Union College laboratory the men would be turned their way, on the other hand, there would be a strengthening of the university department through the influence of the great research laboratory at the works. The third proposal which I heard last week was this: it seemed to meet with little favour, that university classes should be conducted inside the research laboratories of an industry. These people seemed to feel that the supply of men from the universities is so limited, and is becoming of such a character, that they cannot utilize them very readily as they come in. That proposal was actually made, that university men should go to the laboratories of the works and conduct classes there so that their research workers in the laboratories could have association with university men. Prior to the war, perhaps no country had done so much in the direction of solving industrial problems as Germany.

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Mr. THOMPSON: Do I understand that the research workers in these industrial laboratories are not university men?

PROFESSOR CLARK: No, they are, I think, almost all university men, but Dr. Whitney and Dr. Jewett, and men of their type seem to feel that the supply is too limited, and that the character of the training they get is not quite what they want. That is to say, they do not come in thoroughly equipped as research workers.

Mr. NICKLE: That is from the universities?

Professor CLARK: From the universities. The point I am trying to make is, that the best men who ought to be in the universities training younger men for future work are going to the industrial laboratories and to the Government laboratories, leaving the universities less well equipped for the training of future workers.

Perhaps no country in the world, had, prior to the war, done so much in applying scientific research to industrial as Germany. That was due to her broad system of federalized scientific education. In that country, many factory managers held post-graduate degrees. It was not superior scientific ability that gained Germany her success, for they were not equal to those of England, for example but rather to have greater attention to the training of men and the better understanding of the place of the scientist in the industrial system.

Another advantage that would accrue from the establishment of research centres in university laboratories is the very great value that comes from the contact of pure and applied science. The pure science of to-day is the practical matter to-morrow. Then again, the methods and equipment of the industrial laboratories are of tremendous aid to the worker in pure science. Much of the equipment is common, much is not common, but I believe that the very great success of the General Electric's laboratory at Schenectady is due to the constant intermixture of the so-called pure and applied science. Recently, I tried to get one of the best men from one of these laboratories to take a position at Queen's University. He is largely a pure scientist, but he declined on the ground that the opportunities for research in that industrial laboratory were so much better than in the average university laboratory that he felt he could accomplish more as a pure scientific worker in the industrial laboratory than he could in most of the university laboratories. Any attempt to separate what we call pure science, and what we call applied science will work out to the detriment to both. There is no dividing line. It is impossible to say where pure science begins or ends, and where applied science begins or ends. The over-lapping is so great, and appears in such unexpected ways and places, that it is a very dangerous thing to try to separate them. For example, Dr. Davy of the General Electric showed me last week some pieces of metal that had been japaned, covered with a hard resisting black varnish, and with much grief he told me that he arrived at the method for doing this work through some experiments with the X-rays trying to kill the parasites in cigars. That is, his experiments led him to a new process for japaning metal. What the process is, I do not know.

Whatever plan is to be adopted for Canada, I should like to appeal for a Bureau Standards founded on a modest scale to keep pace with the needs of the country. At present, if I wish a thermometer calebrated or a set of weights standardized or some electrical instruments tested, I must send them to Washington. That should not be. We should have a place here in Ottawa where such instruments could be sent and taken care of at once. We should have provision for this kind of work so that this obstacle to research may be removed. These standards laboratories should contain facilities for testing and standardizing all kinds of scientific instruments, should have facilities for standardizing materials, and for researches in connection with standardizing work. But in all of them, the Bureau should be the servant of the research workers of the country and not their master. Autocracy in research would be fatal, and any attempt of a single laboratory to direct or control research would be most detrimental. To

draw a large number of research workers in the country into such a laboratory in a large country like this would mean that for the most part the laboratory would be too remote from the people to excite their interest. The large number of men required would be removed from universities or localities where this interest might be kept up. The local interest should be held. The problems in different parts of the country are different. The people do not think altogether the same about the problems. It would be better for the problems of British Columbia, for example, to be studied out and solved there where the people would be in touch with what is going on near the seat of these problems. I predict a far greater interest in them. Then the independents of point of view of the different laboratories working not necessarily in the same fields, but in similar fields, a something that should not be overlooked. Two men never do things in the same way, and two men working on the same problem arrive at different results, particularly if they work independently of each other, and do not know each others work too intimately.

But what seems to me the strongest plea is the gradual scientific education of the people by means of which they can come to understand the importance of research in connection with the life of this country. In this direction, I believe that several centres of research will produce far greater results than a single centre. We are not yet a scientific people, and we need to become much more so. The more laboratories we can have solving the problems of the country, the more people will come to realize the importance of this work and the more heartily will they support it. Any movement for the development of research which does not consider or provide for the education and training of the workers who are to be needed in the next generation, will fall far short of the success that we ought to have. We depend so much on the understanding of the people, and the more closely the movement can be brought into touch with the people, the more quickly will they come to see the importance of it. My feeling is that we should build on a fairly broad foundation, and not start with a central laboratory which would absorb too much of the scientific work of the country, and leave the universities stripped, to some extent, of their men who are needed so much for the training of the workers to come. I thank you for listening to my views. The opinions that I have expressed are opinions developed from some years experience in research work. I may say that I am Director of Research at Queen's University, and am therefore keenly interested in the success of this movement which is for the development of scientific research in Canada. Anything that can be done to bring about a better understanding of scientific research in Canada, and an increase in the amount of it, is for the very best interest of the country. My feeling is that instead of establishing one great laboratory in a certain centre, we should endeavour to get these universities of the country which are in a position to carry on the work, get them in touch with the industries to the establishment of laboratories within their walls. I feel that we shall have solved nearly all the problems, if this can be done, of linking up the universities with industries, of teaching the people the importance of research, of providing for the future workers of the country, and putting the whole system of scientific research on a broad and secure foundation.

Mr. SHEARD: I would like to have the privilege of asking a question or two, and I wish Dr. Clark to understand that I am asking for information only, and not in a critical sense. I would first ask if he, as Director of Research, has any other professorial or educational duties to perform.

Professor CLARK: Yes, I occupy the chair in Physics.

Mr. SHEARD: That being the case, having had some experience in university matters and in university work as a teacher, I would like to be clear in my mind whether there is any possible danger of a confusion of our work with pure technical education.

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Prof. CLARK: Undoubtedly there is a danger, but the danger can be removed.

Mr. SHEARD: To make myself clear to the Committee, I may illustrate by saying that I had charge at one time of a microscopical laboratory at a university. We were engaged in some degree, and were very pleased to be engaged, in research work of a microscopical nature such as, for instance, the application of analine dyes to the human tissues. It was a very attractive subject, but it would not be, in my humble judgment, very fertile in results along the lines which I think this Committee is aiming at, namely, the conserving of the resources and wealth of the community. That is one of the objections which I would like to see removed, if your plan is carried out, and if you could just elaborate on how that could be done, I would be pleased.

Professor CLARK: The way we are trying to work it out at Queen's is this: I expect to be relieved of my professional duties just as rapidly as the research department develops. That is left to me. I can be relieved of such professional duties as may seem advisable to drop in order that I may give my attention to the direction of the research department. But I feel that a slight contact with the student body is almost necessary if we are to attract the young men into that work which I feel is one of the very great advantages of the university system. We get the source of supply. In some departments, of course, undoubtedly it would be true that the association of the men with research would not be so obvious. Take for example the department which deals with microscopical work, though I do not want to say that it cannot be connected up with research. In the Department of Physics, which is closely associated with the engineering school, there is a tremendous opportunity to link up the work of the university with the work of the industrial laboratories. In regard to metalurgy, for example, a professor of metallogy can do very efficiently the work of the research laboratory. For example, in our metallurgical laboratory we have two men, one of whom gives the larger part of his time to research, and only a very small part to teaching. The other gives more attention to teaching and less to research. We do not know how it is going to work out, but it seems to be working out very well so far. The work is so new that I would not say that we have the very best, but we are making the attempt of benefiting industry through the use of our laboratory, and if some other industry can be helped we would like to find a way to help it. We hope to find the best system.

Mr. SHEARD: Assuming that the Government adopted that policy and set aside a certain amount of money to endow the various universities; assuming that the Government gave $100,000 to Queen's University for that work, would there not be a tendency to divide the money among certain departments, say for example, physics, chemistry, and probably biological chemistry, and there might be a separate department of pure science apart from physics or possibly astronomy. Would there not be a tendency to do that. Of course, there would be demands from any department that thought it had some connection with scientific research. I am speaking of the various branches of the one institution.

Mr. NICKLE: You are speaking of the intra-mural allocation?

Professor CLARK: Yes, I think there might be a danger of something of that kind happening if it were not very carefully safeguarded, but it seems to me the situation could be saved by giving only to those departments which are serving some definite industry or some definite need of the country, letting the university take care of its own research work, such as pure science, but such funds granted to such university might, at first at least, be tried out in certain lines and restricted to these lines.

Mr. SHEARD: Could the universities not assist by selecting from their science graduates, or those graduates who have an intimate knowledge of one or more branches of applied science, the men who, they thought, by their college course had a faculty,

or a qualification for original scientific work, and then transferring them to pursue that idea in the national institution? What would your opinion be about that?

Professor CLARK: That is quite possible, but based on my own experience of the last few years, and the experience of other men who are very closely in touch with this kind of work, my answer is that these men are not attracted into that field as readily and as quickly. They do not feel the touch, they do not feel the influence of the work as they do when they come in contact with that work which is actually going on right under their view. For example, in our own work we find the men attracted to these fields by seeing the work going on, and the news of that work going through the university is bringing a large number of men to that work, and that is where the necessity for the association of these young men with this kind of work appears, in order to get the men to the work early and get them started. I find that they see the work going on, and then they want to go in. That has been my experience for the last year. Here is a piece of work going on, and they ask: "Can we not get into this?"

Mr. SHEARD: If a graduate wished to pursue that work, which would take two or three years at least, I should think, some provision would have to be made for his maintenance and a sum of money paid to him in the shape of an emolument, to keep him, to reward him, and to make it worth his while. Would that not be necessary?

Professor CLARK: Oh, yes.

Mr. THOMPSON: You referred to the application of science to the industrial supremacy of Germany before the war. Did the German Imperial Government subsidize industrial research?

Professor CLARK: My opinion is not very definite on that point.

Professor FIELDS: Not for industrial research in any case, but they had an engineering school.

Mr. SHEARD: Some years ago, when I took a nine months' course in Germany, as I understand the system was to provide free education and educational facilities in particular lines of construction and development which the various students might choose to select, and that was the *modus operandi*.

Mr. THOMPSON: Did the German Imperial Government have a central laboratory?

Professor CLARK: Yes, there is a central laboratory.

Mr. SHEARD: Subsidized by the Federal Government?

Professor CLARK: Yes.

The CHAIRMAN: At Charlottenberg.

Mr. THOMPSON: Do I understand you to say that you are in favour of a Bureau of Standards?

Professor CLARK: Yes.

Mr. THOMPSON: I gather from your remarks that you are not in favour of the institute side of this bureau. We have been referring to it as a Mellon institute. I would like to ask your opinion as to whether you think, in the event of the institute side of the bureau being established it would offer a field which does not now exist in Canada for post-graduate scientific work.

Professor CLARK: Please repeat your question?

Mr. THOMPSON: There are only two universities in Canada giving post-graduate work in science?

Professor CLARK: Yes.

Mr. THOMPSON: You say the great thing is to have a source from which to draw the scientific men, and a field in which they would do the work?

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Professor CLARK: Yes.

Mr. THOMPSON: Would this institute side of the bureau offer a field?

Professor CLARK: I think it would, but not to the extent I would like to see the field develop.

The CHAIRMAN: Professor Dayton C. Miller, Applied Science, Cleveland, is here to-day and the Committee would like to hear from him.

Professor DAYTON C. MILLER: I feel somewhat embarrassed in the situation, because the question, as you have it here, is one about which I know nothing whatever. I am entirely unprejudiced, as far as your questions are concerned, and I have been engaged for nearly thirty years in teaching physics in the School of Applied Science in Cleveland an engineering college, and we have to do very largely with industrial problems and industrial research, and the school is primarily for applied science. I may say that I am fairly well acquainted with all of our large research laboratories. I have known the Bureau of Standards since its organization, and known all of its principal men, and acquainted with the Westinghouse laboratory, and the one at Schenectady, and the Cleveland laboratories, such as the National Carbon laboratories, and a great many other industrial laboratories of smaller sizes, and I have had occasion to see a great many students who have lately gone into these laboratories in the Bureau of Standards at the present time.

In the Bureau of Standards, I have eight of my own students at work, and some are going into the Western Electrical Company, the General Electric Company, the International Carbon Works, and other large industries. The head of the International Carbon Works is one of my graduates. A new laboratory in connection with one of the large industries at Cleveland has just been started in which some of my students are concerned. I could name many others. I have talked with Professor Duncan, who originated the Industrial fellowship, and who established the Mellon Institute. I have had direct personal communication with four specific industrial fellowships in colleges. So that, while I am not well acquainted with the particular questions at issue here, I have some rather definite opinions with regard to the relation of research to industries, and perhaps I may make a few remarks at random, and then perhaps any questions that may be asked will bring out more clearly my views. I have had occasion to talk with many scientists about the conditions which Professor Clark has brought to your notice. We talk a good deal about them in our country, both industrial and college men. I have been in Washington a good deal during the last year, and three or four weeks ago I was at a meeting of the National Academy where the question of the relation between industrial laboratories and colleges was discussed. Some of the difficulties mentioned by Professor Clark are prominent in the United States. The fact is that the industrial laboratories are draining the college laboratories of their best men, and that is due to the fact that the salaries in the industrial laboratories are larger than those offered in the colleges. I find that my own students are inclined to go into the industrial laboratories rather than remain in university work. There is a difficulty in getting proper instructors. In connection with my work in the School of Applied Science, I have my own interests in the pure science side of the question, and have throughout many years been carrying on scientific research. My personal feeling is that scientific research of a fundamental character is of the utmost importance, but I also feel very strongly that any industrial entanglement of that scientific research is detrimental. I do not know where one could be in a position to realize the conflict between the two than in my own position, because we are continually being called upon by the industrial people to solve certain problems. We are called upon for certain work, but we try to keep clear of them and stick to the scientific aspect of the problem. Specifically, I have been studying photo-

graphy, and the analysis of sound waves. It is a new development which is being carried out in other laboratories and I want to develop that as a general method of research. I had not been at this work more than two years when a large manufacturer of ball bearings in the United States hearing of our work applied to the president for a permission to endow an industrial fellowship and to have a man come to my laboratory. They said they would pay all expenses, and he would nominally be my assistant. They were interested in the noises produced by ball bearings, and our president thought it was a splendid idea because it would link up the industrial interests with the college. I saw that if a man came to my laboratory, he would not only take up my time, but he would be expected to work continuously, while I work at intervals. He would use our apparatus, which had cost thousands of dollars, and which we could not duplicate, because it would take years to provide it, and I also realized that if he came there I should be nominally his assistant and would have to help him to develop this research problem for the ball bearings company. I absolutely refused to have a man come into my laboratory. I did however, without any charge spend three or four weeks studying the noises produced by ball bearings, and sent them a report. We had another industrial fellowship, and a gentleman came to the School whose problem was to investigate something relating to paints in the metallurgical line. I gave him a room, and he went to work. He seemed to feel that he had the privilege of using not only that room, but the services of the members of the faculty. He came to the members of the faculty for advice a dozen times or more in the course of the year. We would talk two or three hours about his problems, and it was my duty as a member of the faculty to advise him. He stayed there for a year, and did some work for his concern. They patented the device, and informed us that they did not want any more facilities. All the other members of the faculty felt the same way as I did. I agree very heartily with the idea that there should be a central laboratory. I do not know much about the points that were discussed by Dr. Clark, but I do feel that while the Government should support research and provide a place for the solution of problems in the industries, those facilities should not be confined to individual concerns, but should be available to anyone who wishes to make use of them. I feel that in the colleges research should not be hampered by any direct industrial associations or relations. The difficulty still remains that the industries attract the young men, and I think something must be done to make college research equally attractive in order to train young men. Instead of yielding to the industrial pressure, I would prefer to see some effort made to bolster up universities in some manner. That, perhaps, is your plan. They should be helped so that they can carry on pure scientific research independent of industrial control. Then they will be able to provide the men. I had a student who has just made good. He went into the General Electric Company's laboratory where they have one thousand two hundred trained workers in research. He is now one of their leading men, and gets a salary of $6,000 a year. I saw him recently, and asked him how he would feel about retaining a place in the industrial laboratory or going back to a college, and what inducements he thought the college should offer. He said that he thought most men would feel as he did that if the college could offer two-thirds of the salary offered by an industrial laboratory, a great many of the best men would prefer the college atmosphere of pure research rather than the industrial laboratory. He said that while the laboratories of the Western Electric Company were splendid they felt under an obligation to make good in industrial research. They were allowed to do a good deal of scientific research, but it was understood that they must make good in the industry, and he personally would prefer to be in a pure science laboratory. In Cleveland there has been much discussion over the establishment of a municipal university. The municipality taxes itself and contributes to education, and one of the strong arguments used by the City Council was that the college would have its professor of mechanical engineering and

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its laboratories, and that when the city had some problem of municipal investigation to undertake it would only need to send to the college to have it done. We are opposed to the idea because we feel they would simply overwhelm the college and the research workers and make them servants of the City Council instead of allowing them free to do their work. We have therefore been fighting the proposal. I support the idea of Government assistance to research, the Bureau of Standards' idea, and the encouragement of research in the universities in whatever plan might be deemed wise. I think they should encourage it in all universities, but my own opinion is that such research should be entirely removed from any industrial supervision or control, or from anything more than mere suggestion.

Mr. NICHOLSON: Your position is that the university should be an educational institution purely.

Professor MILLER: Yes, I think that research men for the industrial laboratory should get their fundamental education in a university atmosphere. They need additional instruction, as Dr. Clark indicated. Their general education should be obtained in a university atmosphere, and not in connection with colleges. The University of Cincinnati is teaching its graduates by sending them into the shops for part of the time. We have studied that with great thoroughness as to whether we should connect our laboratories with the city, and we are very decidedly of the opinion that we should not. We think it is not desirable.

Mr. NICHOLSON: In connection with the tendency of the better men to leave the university, and to deprive themselves of the opportunity of the instruction accorded by the university if the open door to the pure scientist could be made more attractive, would it not offset that tendency and tend to create a desire on the part of the men to remain in the university until they were equipped in a more thorough manner.

Professor MILLER: I think there is a tendency of that kind, but there still remains the difficulty that as soon as they are equipped, whether as graduates of engineering or in post-graduate courses, for many of them go up for the doctor's degree, many of the better men are attracted to the industrial laboratories by the greatly increased pay. Some of these men ought to remain in the universities to continue instruction. We are not quite disabled as yet, but there is a tendency to leave the universities without adequate teaching forces.

Professor FIELDS: But pure scientific work has a greater attraction for these men?

Professor MILLER: I think that was pretty clearly brought out. At present, I am looking for an assistant professor of Physics, and I find that a number of men are willing to return at a reduced salary, that is at a lower salary than they receive in the industrial laboratories. Specifically, the colleges have been paying a man for his first year's work from $1,200 to $1,500. I was told ten days ago by the Western Electric man that the average research man in their laboratories was paid $2,400.

Mr. SHEARD: Do you think that the best training for research work is in the pure science department?

Professor MILLER: I do, particularly for the fundamental training, until he has got his degree. I am firmly of that opinion. The man should be rather free from specialized industry until he has got his doctor's degree.

Mr. MCGIBBON: The difficulty is that the intensive commercialism of the present day offers a man a better salary than he would get in the universities.

Professor MILLER: That is the difficulty.

Mr. NICHOLSON: Would it not rather appear that the necessities of the industrial situation were opening up a larger field for the scientific worker? What is required is a greater number of men.

Professor MILLER: A great number of men, and they must be trained in the highest possible degree. I was speaking to Dr. Lang Muir, one of our industrial research men, and he expressed the view that the remedy was to train these men in the colleges. He felt that the colleges should either have funds appropriated from the Government, or raised by taxes or by increased tuition, so that they could offer inducements to the better men to remain on the teaching staff to train men for the industrial laboratories. The difficulty is to retain the best men on the teaching staff. Dr. Lang Muir was of the opinion that while the tendency is for the best men to leave the universities, the colleges must make their work more attractive, and he wanted men trained in pure science, not in the industrial laboratories.

WEDNESDAY, June 4, 1919.

The Committee met at 10.30 a.m., Mr. Cronyn, Chairman, presiding.

The CHAIRMAN: We have Doctor Miller, Professor of Physical Chemistry in the University of Toronto, with us to-day, and I presume it is the pleasure of the Committee that he be heard.

Dr. W. L. MILLER: I thank the Committee for the honour done me in inviting me to appear before it, and also the Secretary for having sent me a copy of Dr. Macallum's address in which certain concrete proposals were laid before the Committee. I am glad to say that I find myself in substantial agreement with most of these. I am glad to give my support to the work of founding an institute of research and to bring the support of a number of gentlemen whose names I shall give.

There is one matter which I would like to deal with first. A question was asked by Mr. Nickle, "Which is cause and which is effect? Is it the lack of demand by the establishments, or the lack of supply from the universities that makes so little research work in Canada?" Then again Mr. Nickle asked "You think that if the universities had produced the men, the industries would have absorbed them"? Again he remarked "So that it is the universities' lack of appreciation that led to the small number of men being employed by the industries". These were very general questions, and the answers had to be given in a very general way. I should like to supply some information as to our experience in the case of chemical industry, which I think will throw a good deal of light on that phase of the subject. If a student in Toronto wishes to take a university course in chemistry, he takes the honours course in the faculty of Arts. For some time there has been a similar course in the faculty of Applied Science which has now been amalgamated with the Arts course; they approached so closely to each other that they were turned into one course. This honour course in Arts includes instruction in chemical research to all students who take it. That has been the law and the practice since 1892, that is to say for 27 years. During all that time, any student in the university who took the honour course in chemistry had, as part of his undergraduate work, instruction in chemical research. During the last 15 years or so, practically the whole of the fourth year has been devoted to research. There are some five lectures a week, and some of the students who wish to teach spend a few hours a week in the biological laboratory, but all the rest of the time, during the fourth year, is devoted to chemical research.

Mr. NICKLE: That was compulsory?

Dr. MILLER: Yes.

[Professor Dayton C. Miller.]

Mr. Ross: Laboratory work?

Dr. Miller: Yes, practically the student's whole time was devoted to research. These students were divided up among the professors, so as not to bunch them, and now that there are more we are making a further division.

In this we differ from the practice of the American Universities, and anticipated the recommendation of the Royal Commission on the University of London, and that of the recent Royal Commission on the teaching of Science in England. The latter body urged a fourth year of research after three years' preliminary study; we have the advantage over the English Universities that here this fourth year is compulsory, whereas there a student may leave the University with his degree after the three years' preliminary training. We have had experience of the results of such an option. In the Faculty of Applied Science they used to give a Diploma at the end of the third year, and a Degree at the end of the fourth year; until the Diploma was discontinued, never more than half the men stayed for the fourth year—our students are not rich men, and many felt they had to go out and earn their living at the earliest moment.

In thus providing training in chemical research, the University of Toronto does not stand alone in Canada. Professor Ruttan of McGill informs me that there is a somewhat similar arrangement for the honours chemistry students studying for the degree of B.Sc. and I understand that in Queen's University a similar arrangement is in force, or in contemplation. Perhaps I should say that when speaking of the University of Toronto, I am not trying to advertise that university or to make invidious comparisons between the Canadian universities. I merely refer to it by way of illustration, and because it is the university with whose work I am most familiar.

The student who made a beginning in research in his fourth year, and who wished to continue research after graduation, had opportunities for doing so. During the year before the war broke out there were ten assistants half of whose time was reserved for research; five half days per week were given to helping in the large laboratory classes, and the other five half days, and the whole of Saturday, were devoted to research. Some of these men stayed two years, or even three; we did not encourage them to stay too long, but from what I have said it is plain that there have been good opportunities for a man to learn to carry out chemical research in the University of Toronto. There have never been very many men in the honour chemistry course; I think that half a dozen graduates per year would be about the average during the 27 years. We never tried to induce large numbers of students to take up this course, and I am going to tell you why we did not do so. I am going to give you the facts which led us to take that course, by telling you what became of the men who took the course. To begin with a number have become professors. One of them is a professor in British Columbia; two are professors in Macdonald College, and one in the University of Bishops College, and for some time there was one in the University of New Brunswick. One is in the University of Bristol, he is the only one in such a position in England. Now where are the others? They hold chairs in the State Universities of North Carolina, Alabama, Wisconsin, Nebraska, Utah, Michigan and California, in the Michigan school of Mines, and in the Minnesota Agricultural Experiment Station; one has just been offered an appointment in Ohio. Twelve in the United States, as against four or five in Canada (excluding members of the staff of the University of Toronto itself). I should not forget to mention that the late Robert Kennedy Duncan, formerly professor at the University of Kansas, who began the work the Mellon Institute was founded to continue, was one of our graduates, and received his first training in research in Toronto. Every year we receive, and are glad to receive, papers giving accounts of experimental researches carried out by these gentlemen or by others under their direction; they are doing good work—in the United States.

Now I will tell you what happened to the other graduates. Some are in the Government departments; in the Department of the Interior in Ottawa, in British

Columbia, in Saskatchewan, and throughout the West. Others are connected with the experimental farms in Ottawa and in the West. Some are in the Mines Branch, some in the Ontario Bureau of Mines and Bureau of Health or in the civic laboratories of Toronto, Edmonton, and Saskatoon, and some have found employment in the mining region north of Toronto, at Cobalt, Victoria Mines and Sudbury. A few—Dr. McCallum told you there were not many, and he was right—are in Canadian Industries, in the Canadian Consolidated Rubber Co., for instance, in the Partridge Rubber Co., and in the Gutta Percha and Rubber Co.; in the Northern Electric Co., the Canadian National Carbon Co.; at Shawinigan; and in the Atlantic, the Dominion and the British Columbia Sugar Refineries, etc. But, as in the case of those who have gone into academic work, the greater number, and the best paid, are south of the border, in rubber works, oil, gas, soap, salt, abrasives, explosives, electrochemical works, etc., not doing routine work under somebody else's direction, but in responsible well paid positions. We keep no list, and my information is derived from private letters and conversations and chance meetings, but I know that one of these men receives $15,000 a year, another $8,000, another $5,00, and a number 3,000 and $4,000; several are managers of chemical works, one is the head of the research laboratory of a large corporation and a number of others are on the staffs of other research laboratories, two that I know of (in Michigan and in Illinois) are at the head of successful companies manufacturing products invented by themselves."

"I think these illustrations will help to make it clear why we did not try to get more men into the chemistry department. We were turning out half a dozen men a year and Canada did not need that number. If we sent out more men they would simply leave Canada. We knew that, and we deliberately did not try to boom that department in order to get students into it." The same thing went on during the war, although the Professor of Chemical Engineering and I compiled a list of eighty men from the two departments (not nearly all of them graduates, of course) doing chemical work for the British and Canadian Governments. At the beginning of the war there was a great cry for picric acid; the making of it involved the use of potash, and potash was not to be had. In the laboratories of the Faculty of Applied Science they found how to substitute soda for potash, and established a process in 1915 which turned out four or five tons of picric acid per day. But where? In Perth Amboy, New Jersey. There was a shortage of magnesium; the Electrochemical laboratory found out how to make that metal, substituting soda for potash as in the other case, and in January, 1916, a plant was in operation which finally produced 400 pounds of magnesium per day—that plant was set up at Rumford, Maine, but this was not the fault of our Canadian Universities.

The same thing is going on yet. Last year one of our graduates left a laboratory of the Government here in Ottawa, where he was looking forward to $1,800—to take a position in a United States company at $3,000—initial salary. Two of the men who recently left the Forest Products laboratory have gone to the States. A gentleman employed in chemical research at Winnipeg by the Hon. Advisory Council was successful in his work, and was promptly offered a position in a Pittsburgh company, where he now is.

It seems to me, Mr. Chairman, that I have supplied material for an answer to Mr. Nickle's question:—"Is it the lack of demand by the establishments, or the lack of supply from the universities that makes so little research work in Canada?"

Mr. NICKLE: Do I understand that you say the universities would have supplied the men and could have supplied them, provided there was a demand in Canada for them?

Professor MILLER: I put it stronger than that. The universities did supply the men, but we could not place them here, and the reason was not that the men were no good, for they have made a great success of their work in the United States.

[Dr. W. L. Miller.]

APPENDIX No. 5

Mr. NICKLE: Were there greater commercial and financial opportunities in the United States than in Canada?

Professor MILLER: Yes, without comparison. We saw these things a long time ago, as far back as 1902 we were just as clear about this subject as we are now. We saw what had to be done was to get up a little propaganda, and I think nothing the Advisory Committee has done has produced better results than their efforts to let people know what can be done in the industries here, and what is being done elsewhere. Our plan was to found in Canada a branch of the British Society of Chemical Industry. There are now 380 members of that society in Eastern Canada, and another fifty in British Columbia. These different Canadian sections of the society are now getting together so that all the members in Canada will have one central organization. I am asked, I take it, how can this Committee of the House of Commons help the application of science to industry in Canada. My experience leads me to say that propaganda is one of the things needed. My impression is that you cannot get any better propaganda than through the Society of Chemical Industry, because this society is not composed exclusivly of chemists, but a great many manufacturers belong to it as well. The Chairman of the Hydro-Electric Power Commission, for instance, is a member, and the General Manager of the Consumers' Gas Co., the General Manager of the W. L. Davies Co., heads of iron, lumber, leather, glue, varnish, paper, milk companies, etc., etc. I will give the Chairman a copy of the membership list, with a mark opposite the names of members who are not professional chemists, but manufacturers, etc., there are some 65 of them; my object is to show that this is not a purely professional society. Such a society is in a position to do a great deal to help the situation now existing. If they received a grant from the Dominion Government it would be possible to establish branches all over the country, in addition to those now existing at Toronto, Montreal, Ottawa, Kingston, and British Columbia; these branches bear their own expenses, but without a fund to pay the expenses of an organizing secretary and of men to address the meetings, progress in founding new branches is very slow. I do not suggest a large sum, say $5,000 a year, and if this does not result in doubling the membership in short time it might be discontinued.

Mr. THOMPSON: What would be the justification for paying money out to this society?

Professor MILLER: The object of the society is to get managers of technical businesses who are not chemists to see the advantage that would accrue to them through the employment of scientific assistance. It is the same kind of propaganda that has been done so well by the Honorary Advisory Committee, but I think it can be done better through this Society, because this society contains in its membership most of those engaged here in doing scientific chemical work in technical industries; they are personally acquainted with the manufacturers, and, if I may answer the question a little flatly, propaganda by men like that has a great deal more effect than propaganda by a professor. I am a professor and I have tried it. These people work in the plant, they bring a friend in, and he brings a friend in, and in a year these men are members, and increase the influence of the Society. I am inclined to think that is the way in which money spent on propaganda would bring in most returns, but I would not suggest a permanent grant; try it and see whether there is a good result, and if so increase the grant. A manufacturer who joins shows this much interest at all events, that he is willing to pay an annual fee to the Society of seven or eight dollars. I will leave with the Chairman a recent number of the Journal of the Society of Chemical Industry, and copies of some of the papers that have been read before the branches in Canada; these may help to give the committee an idea of the work done by the Society.

This finishes the first matter I wished to bring before the Committee. In the branch of science with which I am concerned, at all events, the Universities are turning out more capable research men than find employment in Canada, with the result that

many leave the country. To remedy this what I have called propaganda is necessary; I have pointed out why in my opinion the Society of Chemical Industry is the best existing organization for this purpose; and I have suggested that a moderate grant to that society would be the most efficient and economical method of obtaining the results desired.

The second way in which I wish to suggest to the Committee that money should be spent—because I take it that is the way the Committee proposes to help—is in connection with chemical literature. One thing that scientific chemists cannot get on without is the German "compilation" literature, the books that contain an account of all chemical work that has been done throughout the world, properly indexed and kept up to date that does not exist in any language but the German, and it has been cheaper for English speaking chemists to learn German than to pay for the translation and maintenance of such compilations. If any chemist had come before the House of Commons a few years ago and asked for money to get books translated from German into English, he might have been considered not intelligent enough to be a good chemist, and he might have been asked why he did not learn German; but during the war this question has been taken up very seriously in England by the Chemical Societies there.

They have sent us a proof of the resolution and the conclusions they came to. It is called "The Report of the General Committee of Chemical and Allied Societies, *re* the Question of Publishing Chemical Bibliographies in the English Language." They go into the reasons for coming to the conclusions which they came to, and they point out how the use of the German language has been a great asset to the Germans. I will leave this report with the Secretary of the Committee but perhaps I may quote from it an address delivered during the war by Professor Leblanc of the University of Leipsig on "Germany's Share in the Development of Chemistry". He said:

> The manifold scientific results are causing chemical literature to expand to an unparalleled extent, and from year to year the importance increases of a reliable means of reference by the preparation of detailed hand books and of literature registers. The problems have been faced on the German side in a praiseworthy manner, and two and a half million marks (£125,000), have just been collected for the further expansion of literary activities. Up to the present time, no other nation commands such organized information, and it is practically impossible to make up the initial German advantage. Every foreign chemical student is obliged to fall back on German chemical literature, and in this manner chemistry acts as a missionary of the German language.

Even during the war the University of Toronto made it compulsory for every student of chemistry to learn German. He has to take a three years' course of it because he can not get on without it. This English Committee proposes to replace these German books that we have been using for years, and they have ascertained how much it is going to cost. They are only going to bring out four books. One is on organic chemistry, one on inorganic chemistry, one on physico-chemical data, and the fourth on organic chemistry patents. These books will cost $550 a set, but I may explain that the first "book" has 18,000 pages, the second 16,000 pages, the third 1,200 pages and the fourth 18,000 pages, and each, of course, will be bound in a number of volumes.

Mr. THOMPSON: Your idea is to have these books translated into our language?

Professor MILLER: Not merely to have them translated; the idea is to have them re-written in English and kept up to date. They estimate the cost at £129,000, that is over $600,000, and if they sold every copy they would make a profit. But what chance have they to sell 2,000 sets of a book which costs $550 a set? Do you think it would be a dignified thing for the Dominion of Canada to bear 15 per cent or 20 per cent of the deficit?

APPENDIX No. 5

Mr. THOMPSON: Why? We can get these books, can we not?

Professor MILLER: Certainly you can by paying $550 a set.

Mr. THOMPSON: What do you mean by a set?

Professor MILLER: One copy of each of the four books I have mentioned. Of course whether the Dominion Government does anything or not, the larger Universities will get these books, in my opinion, however, apart from the obvious political and sentimental advantages of having such works in our own language—Professor LeBlanc has set them out for us in the passage I quoted from the report—the greatest practical advantage from their publication will accrue to men who from lack of early opportunity or from any other reason are ignorant of the German language. To all such, at present, the most important books for the research chemist are illegible.

Mr. THOMPSON: Your idea is to get the Government to provide the money to buy these books?

Professor MILLER: I would suggest that you give a grant towards the expenses of publication. This might perhaps take the form of an order in advance for ten or fifteen complete sets at double the price proposed; in that case the books when they arrived could be distributed where they would be most used. Of course we do not need to do anything to help on this enterprise; I believe that with or without our help it will be carried through. But the work is for our good as well as for others; we too have proclaimed ourselves interested in the advancement of scientific research; here is an important enterprise getting under way—let us do our share with the rest.

Mr. THOMPSON: Before we can ask the Government to do these things, to take money out of the public treasury, we must be in a position to explain to the public what the object is.

Professor MILLER: I quite appreciate that. The reasons why our government might well support this project for the advancement of scientific research among English speaking peoples are set out in the printed copy of the report which I have placed in the hands of the Chairman. That is the second matter. The third and last thing I propose to deal with is the question of the research institute advocated by the Honorary Advisory Council. A year ago this matter was brought before the meeting of the Royal Society in Ottawa, when the following resolution was adopted on the recommendation of Section III of the Society:—

> "That this Society urge upon the Government of Canada the establishment of a Dominion Laboratory for scientific measurements similar to the United States Bureau of Standards; and that the following be appointed a committee to confer with representatives of other scientific societies, and to make recommendations as to the organization of the proposed institution: Messrs. E. Deville, L. V. King, O. Klotz, A. S. Mackenzie, W. L. Miller, and Stansfield."

A similar resolution was adopted by the annual meeting of the Canadian section of the Society of Chemical Industry, and a similar committee was appointed.

After discussion with the members of these committees, I drew up a detailed plan and sent a letter, a copy of which I have here, to each member, and obtained their comments on the plan. I have brought these comments here so that you may have an opportunity of reading them. There are letters from Messrs. Deville, Ellis, Goodwin, King, Klotz, McIntosh, Mackenzie, Stansfield, Wardleworth, and Burton. One feature that was new at the time these suggestions were made was the appointment of a Council or Board for the proposed Institute. I will just read a paragraph from page 3 of the circular letter:—

> "To keep the interested public in touch with the institution there should be a Council, consisting of members appointed"

[Dr. W. L. Miller.[

and the consensus of opinion was for two or three years

> "by the Government, the Royal Society of Canada, the Canadian section of the Society of Chemical Industry, the Canadian Society of Chemists, and the Canadian Manufacturers' Association."

The members were asked to suggest what others should be on the Council, civil engineers, mining engineers, universities, etc. It was suggested that this Council should meet at regular intervals, not less often than four times yearly, and that their expenses should be paid; that they should have the fullest information as to the work in progress or contemplated, but that the responsibility of deciding what was to be undertaken should rest with the directors; that an annual report should be issued by the Council jointly with the directors, and that applications for grants should be made through the Council. Through such a body, the members of the important scientific and technical societies of Canada would be kept in close touch with the work of the institution and could have their views and wishes brought to the immediate attention of the directors. The latter would find the Council of the greatest service in dispelling misapprehensions, and in gaining public support for their work. I believe I am right in saying that this Council or board is part of the scheme that is now under consideration. It seems to me that it might properly be part of the duties of this board to listen to applications from a university or from one of the Government Bureaus here in Ottawa. Such an application might say in effect: Here is a piece of work that we think ought to be done; we can do it in our laboratory more conveniently than you could do it in yours. Will you therefore help us to finance it? The Council should listen to such an application and if they thought favourably of it they might provide for it in their estimates, and thus in effect go to the Government and ask for the necessary money. I think such a scheme would give the universities a chance to ask for what they want. The Council of the proposed Institute would have to take the responsibility of refusing or concurring in the application.

Mr. Ross: What position does Queen's University take up? Does it take the position that the universities should turn out these research men?

Professor Miller: I think they would like to see direct grant from the Government to the universities.

Mr. Ross: For research work in the universities?

Professor Miller: Yes.

Mr. Ross: Have you not rather strengthened their case in that regard?

Professor Miller: I sympathize with Queen's very strongly, but the difficulty I see would arise from the applications of 19 different universities to the Government for a grant. I do not believe that the Government and the House of Commons would consider that favourably, and I do not believe in asking for more than I am likely to get.

Mr. Thompson: That is the crux of the whole question as to the future of scientific research, as I see it. Is the research to be done by the universities, or by some central bureau here? I would like to have from Professor Miller a clear statement as to which system he favours.

Mr. Whidden: Before that question is answered may I say that I am not sure whether Dr. Thompson means specific industrial research.

Mr. Thompson: It is industrial research that I have in mind.

Mr. Whidden: Then may I ask Professor Miller whether he was referring to industrial research or to general research.

Professor Miller: The question you ask makes the distinction I was going to make in my answer to Dr. Thompson. I took the trouble to find out whether the pro-

fessors in the University of Toronto would like to see a "Mellon Institute," or something analogous established in the university, and they would not; of course I didn't see everyone, but that is the general opinion.

Mr. Ross: What was their objection?

Professor Miller: I think their objection is that the Mellon Institute plan is too far from the work they are engaged in. I think the Mellon Institute plan is this: The manufacturer pays, he expects to have the results of the work for his own exclusive benefit, and unless he gets results pretty quickly he will be disappointed, at least I think that is likely. I think the university would be glad to have an opportunity of carrying out some definite part of an investigation that was undertaken by the institute in Ottawa if it were within their powers. The university would be glad, I think, to help to that extent, but I think they feel that they would not like bargaining with manufacturers, because in the long run the university would lose more than it would gain. That, I think, is their feeling.

The Chairman: You think that the practical difficulty is that a direct appeal to the Dominion Government would not result in grants being made to the universities as a whole. You say there are 19 universities. That is one of the practical difficulties as I understand you.

Professor Miller: That is one of the practical difficulties.

Mr. Ross: Would one of the difficulties not be that if a grant were made to the 19 universities, there would be great trouble in apportioning the money. Some would get only a small grant, and it would be ineffective.

Professor Miller: There is one thing I would like to say as regards the small university. Suppose a small university got a grant of $2,000. That would be a very small grant but it would make a great deal of difference to the professor who had the spending of that money in carrying out research work. I think that such a grant given to the smaller universities would lead to the professorships being sought by good men, not because of the salary, nor because of the undergraduate work, but because of the opportunities afforded of doing research work. I do not think there would be any immediate return to the Dominion Government, but I believe that in the long run such grants would be of very great service.

Mr. Ross: Do you think they might do more effective work than the larger universities?

Professor Miller: I can remember when there was only one professor of chemistry in the University of Toronto, and the appropriation for the department (excluding salaries) was $400 a year. You can judge what $2,000 for research would have looked like to us in those days, can imagine good men competing for positions in the smaller universities if such a grant were given.

Mr. Thompson: So far as pure research is concerned, it should be confined to the universities, and industrial research is not included there.

Professor Miller: I would not prevent the institute in Ottawa undertaking pure research.

Mr. Ross: You would not prevent the university from doing industrial research?

Professor Miller: Not if they wanted to do a certain thing and knew that they could do it better or more conveniently than in the other laboratories.

Mr. Ross: You think that if the university would take up that work they could do it properly?

Professor Miller: Yes.

Mr. Thompson: They would have to have a much greater variety of plant than any university in Canada has at present.

Professor MILLER: They would; that is true.

Mr. THOMPSON: How would they finance themselves for that?

Professor MILLER: If the representative of a university applied to the Board of the new Institute, as I have suggested, he would naturally ask to be allowed to undertake work for which he had special facilities of some sort.

Mr. THOMPSON: In all these investigations, we have to evolve some distinct plan which we can recommend to the Government. We cannot ask the Government to establish a central research plant here, and also to subsidize the universities. So far as I am concerned, I am going to support either the one thing or the other.

Professor MILLER: If you proposed to subsidize the universities, would you let the Provincial Governments take the onus of distributing the grant?

The CHAIRMAN: It will depend very much on the temper of the House. I do not know what view the House may take as to giving grants in aid of provincial education. That remains to be seen. It strikes me from what I have heard, that there are two very distinct needs, one the need of the universities for aid from some one to enable them to train the men and to train them first in fundamental or pure science. We need the men, and universities are the only establishments where they can be turned out, and then we also need something to handle industrial research. Our problem is, can we combine those two? We have had the view strongly expressed that the attempt to hand over to universities industrial research would not only produce bad results in the matter of industrial research, but would commercialize the universities and spoil them.

Mr. THOMPSON: Professor Miller is the second gentleman who has expressed the view that universities do not want to handle industrial research because it will result in commercializing the university.

Professor MILLER: Assuming that one of the universities has got very good equipment for carrying on metallurgical work. Suppose some metallurgical work comes before this proposed central institute to be dealt with, I think it should be in order for a representative of the university in question to come before the Board of the Institute and ask whether they would arrange to have that piece of work carried out in the university. That is a very different thing, from the university's point of view, from having technical questions from all kinds of industries brought for solution to the one university without regard to its equipment in the various branches. By listening to applications such as I have suggested, the Council of the central institute could make use of the plant and staff and special knowledge of the different universities without any one being forced to undue expansion.

Mr. THOMPSON: Are we going to ask the Government to subsidize the universities and establish institutes analogous to the Mellon Institute as well? Or are we going to have a distinct scheme and say, "Let the universities evolve a plan and get money from the sources from which they have already got it"? As far as we are concerned, shall we say to the universities, "Continue the work you have been doing, and we will give you a field for the operation of your highly scientific men in our institute." I do not know what the Committee will do, but that is one of the things I have in mind.

Professor MILLER: Do you think it would spoil your scheme if you added that in case the body at Ottawa here decided to take on a particular investigation, they might be allowed to sublet it to a university?

The CHAIRMAN: That would be in the hands of the Advisory Council.

Professor MILLER: In answer to the other question you asked, I should be very glad indeed if this committee could find any way to assist the universities financially in the work they are doing. Speaking for myself, I think that would be particularly beneficial to the small universities, and I believe that, while you might not get any

immediate result, you would build up a collection of good laboratories with good men competing for the professorships. That is one of the cases where you have to put in the money in advance and then wait a little while.

Dr. MACALLUM: We have had a number of applications from Maritime universities for grants for special investigations. These grants must involve the payment for apparatus that should belong to laboratories. As Dr. Miller suggests, there may be small laboratories where grants might be made for payment of the expenses of certain investigations.

Mr. WHIDDEN: Is it well for us at this stage to go into a discussion that will naturally concern the Committee in reaching a decision when we are hearing the witness. These matters should be discussed when the Committee is in session by itself after we have heard the testimony.

The CHAIRMAN: Except so far as a discussion of that kind may tend to bring out expert information.

Professor MILLER: That is the way I understood the question. By way of supplementing my evidence, I should like to leave with the Committee a short printed account of recent work done in the University of Toronto by the School of Engineering research, and a copy of one of the papers from the chemical laboratories.

The Committee then adjourned.

FRIDAY, June 6, 1919.

The Committee met at 10.30 o'clock, a.m.

Mr. Cronyn, Chairman, presiding.

The CHAIRMAN: Mr. W. A. Hamor, Assistant Director of the Mellon Institute, Pittsburgh, Pennsylvania, will address the Committee.

Mr. HAMOR: At the present time, gentlemen, manufacturers in the United States are spending annually ten million dollars in chemical research, and perhaps an equivalent amount in physical and mechanical investigation. The chemical research relates largely to the discovery of new processes, the improvement of existing processes, the cheapening of products, standardization work, and a certain amount of research applied to public service. Some of our biggest corporations find it advantageous to keep before the public the fact that they are engaged in research work, showing that they are progressive, and that they are alive to the needs of the public; and that has led to the organization of associations, research by groups of manufacturers, and in that way we are carrying out a most effective work. The Mellon Institute of Industrial Research, the home of the system of co-operation between science and industry, founded by the late Doctor Robert Kennedy Duncan, in 1907, was dedicated in 1915, and this building, with its equipment, is generally regarded as being a complete experimental plant; in fact, it is the most thoroughly equipped industrial chemical institution in the United States. Our growth has been progressive and steady, and at the present time we have 47 industrial fellowships in operation; on these fellowships 77 research chemists and engineers are employed. According to our system of applied research, a company, an association, or an individual, and in some instances a state or government, may become the donor of an industrial fellowship, by contributing a definite sum of money to the institute for a period of at least

one year. This amount is in every case adequate to defray the salary or annual stipend of the chemist or engineer whom we select to work on the problems, the solution of which is of interest to the donor, and also to cover the purchase of any necessary special equipment, largely apparatus or mechanical equipment. The Institute furnishes the use of its permanent physical, mechanical and chemical apparatus free of charge, provides laboratory space, and every facility for the successful conduct of the work, as well as constant supervision, and an atmosphere which is sympathetic to fruitful work. In addition, we have splendid library facilities and machine shops, where we can turn out any mechanical apparatus that is required. We are able to do that through our private appropriation. That endowment now brings us in a return of $60,000 a year, and industrial firms are in addition contributing $250,000 a year. That makes $310,000 coming in annually. The $60,000 is used to maintain the institution, and to make it an efficient instrument for the industrial fellowship. The industrial fellows are paid from the $250,000 a year, and that also maintains the operation of their laboratories, unit plants, and so on. The usual operation of accepting a fellowship is this. A manufacturer having a problem or group of problems requiring study submits them to the administration of the Mellon Institute. Since we only accept one fellowship in any one field at any one time, this is considered from that viewpoint as well as its importance, because, since we are now spending $60,000 a year and have 47 fellowships, these fellowships each cost us $1,400 a year to operate; therefore we have to be very particular that the proposed fellowship is of enough importance to require our attention for the period of a year. Usually the industrial fellowships are renewed year after year or until the completion of the work. Sometimes the problem is solved in a year, and the manufacturer starts in with other investigations, so that we have fellowships which have been running for five years or more.

There is a variety of problems under study. We have work in bread, yeast, laundering, petroleum, in leather belting, and many other subjects. Each one of the 47 fellowships is in a distinct field of industry, and I think it would be well here to mention some of the things we have done in the improvement of processes. Perhaps our biggest accomplishment in recent years has been the discovery of Arkady yeast food. That has saved the donor of the bread fellowship half a million dollars a year by cutting down the cost of yeast and reducing the amount of sugar used. This donor, the largest baking concern in the United States, has a bakery in most of the big cities of the east and middle west. Arkady yeast food is based upon the discovery of Dr. Henry Kohman and his assistants, that certain salts stimulate the growth of yeast, and in that way cheapens production. These preparations were used by the British and French Governments during the war, and, of course, it was used by the American Government, too. Many other things have been discovered at the Institute. For instance, in the matter of dental cement, before the war various cements were imported from Germany, cements which produced an enamel-like finish upon solidification. We were able to work up a cement which was far superior to any of those, and that has been in the market now for over a year. A little over a year before it was put on the market it was tried out by several hundred dentists in order to receive an expert opinion as to its efficiency.

Another interesting line of accomplishment is in the field of insecticides. In fact, the work of Dr. Hedenberg is said to be the most important accomplishment in applied entomology in the last twenty-five years. Our work on petroleum has been going on for eight years. During that time, we have discovered several new processes of making gasolene, and also important refining methods for petroleum. In addition to that, we have devised processes for making chemicals from petroleum. A considerable amount of work has been done in connection with natural gas. The Institute has also worked out a new process for producing acetylene which is probably more economic than the calcium carbide process.//

[W. A. Hamor.]

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Dr. MACALLUM: Is that on the market?

Mr. HAMOR: Would you like me to explain something about it?

Dr. MACALLUM: Yes.

Mr. HAMOR: Of course I am not privileged to tell much about it. The donor has that information. We have carried the process through the unit plant stage, and the donor plans to put it in large scale operation in the near future. I may also mention some of our work in the field of industrial engineering, and of our work on refractories. There is an organization of 84 of the largest refractor manufacturers in the United States for which we have been doing standardization work, the standardizing of refractory products.

Mr. THOMPSON: What do you mean by refractories?

Mr. HAMOR: A product which will stand a high temperature, like furnace brick, or metallurgical brick.

Mr. THOMPSON: Has it any connection with refractory ores?

Mr. HAMOR: No; except minerals used in the manufacture of brick. There are hundreds of problems in connection with the manufacture and use of refractories. Another investigation relates to new uses for various products, like magnesium. Magnesium was put on the market during the war and there is a big demand for it, but we want to have new uses. We are also trying to find new uses for sulphur. When you consider that sulphur is one of the cheapest materials we have, costing about a cent a pound, there are many possibilities if we are able to get new uses. Some of our best known investigations have been in the chemistry and technology of laundering under the auspices of the Laundry Owners' National Association. We do the work for 2,500 companies, and have succeeded in improving and rendering more effective the various processes of laundering. We have prepared a special manual of washroom formulas which has been distributed to all the members of the Association. In addition, we have worked up separate reagents, like soaps and sours, study bleaching processes and detergents for textiles, etc. We have a little laundry in the Institute. In every case when a piece of work justifies it, we put in a small plant in order to duplicate as nearly as possible the conditions which obtain in the factory. When a process under development gets beyond the laboratory stage, we erect a unit plant near the Institute where the economics of the process are studied. With regard to the relations with the donating companies, each Fellowship which comes to the Mellon Institute is the subject of a definite agreement between the company concerned and the Institute. We have published a brochure about that and I think you have received copies of it. We make no agreement for a less period than one year. The average foundation sum of an individual Industrial Fellowship is $3,500. Of that sum, approximately $3,000 goes in salary to the incumbent of the Fellowship. That is, the Industrial Fellow gets that sum, while the remaining $500 is an apparatus fund.

Mr. THOMPSON: How is your Institute financed? Do you get any Government assistance?

Mr. HAMOR: None at all. Our income is from two sources. First, $60,000 per annum comes from our founders, the Messrs. A. W. and R. B. Mellon, bankers of Pittsburg. The remaining $250,000 comes from donors of Industrial Fellowships. These Fellowships range in foundation sums from $2,500 to $10,000 a year.

The CHAIRMAN: Would you elaborate that a little further and explain to us how the Institute interests those industries? What is the actual machinery for getting a certain industry attracted to your institute?

Mr. HAMOR: Dr. Robert Kennedy Duncan carried on the pioneer work in that connection, and the work was primarily educational. For instance, Dr. Duncan found it necessary at first to call upon industrial concerns which he thought had problems

requiring investigation, and he interested them in the Industrial Fellowship system. We moved into our new building in 1915, and then we passed the experimental stage. We had twenty-three Industrial Fellowships. We have been able to double that from the accomplishments which we have been able to make. At present, we have a waiting list of five or six companies anxious to put in Fellowships as soon as we can find the necessary space for them. We are full to capacity, and there will be only one Fellowship accepted during this summer. That takes the place of one which has expired. We have carried on publicity work in a dignified way. We have brought the importance of research before the manufacturers. As a usual thing, we publish ten or twelve papers a year on the importance of research and we average twenty-five reports of research a year. These papers are distributed to industrialists throughout the country who are interested in these things, and in that way they see that the Institute is doing good work, and that research properly does pay. But what has made our work most attractive, particularly to the small manufacturers, has been that the cost of research at the Mellon Institute has been reduced to a minimum, the founder of the fellowship merely paying the salary of the research man and the cost of the necessary special equipment. We have shown that we can carry out work for $3,500 a year at the Institute, which would cost $30,000 a year to duplicate in a plant laboratory put up specially for that purpose.

The CHAIRMAN: Tell us what becomes of the profits from the patents for these discoveries? Have you any rules governing that?

Mr. HAMOR: Yes, a rule that all discoveries made on any industrial fellowship becomes the property of the donor thereof, and the Institute reserves the right to publish the results of each investigation three years after the expiration of the Fellowship, with the understanding that the publication thereof does not unduly injure the interests of the donor. Sometimes there may be only certain aspects of an investigation reported; but in every case we try to publish the results of our work, although all the discoveries on each investigation become the property of the donor.

Mr. THOMPSON: What is the minimum amount received from a manufacturer or individual or association for the establishment of a fellowship and the time limit of that fellowship?

Mr. HAMOR: We will accept no investigation for a period of less than one year. In that way we show that we do not attempt to conflict with the consulting chemist. We take only protracted inquiries—ones requiring at least a year or so for investigation and solution.

The CHAIRMAN: And the amount?

Mr. HAMOR: The amount is primarily dependent upon the type or research man for the work. For instance, our Fellows' salaries range from $1,200 a year to $5,000 a year. We have at the Institute men who have a national reputation as experts in certain branches of technology. For instance, Howe, Kohman, Elledge, Curme, Garner, and other men of that type, who are known all over the country as our leading men in their lines, and to obtain and keep men of that calibre you must pay good salaries.

Mr. THOMPSON: So that the man applying for a fellowship would have to have enough money to pay the particular type of man they want for the research work.

Mr. HAMOR: Exactly. A man puts in a fellowship and leaves it to us to decide what should be the foundation sum for this fellowship. We select the suitable man, and of course we determine exactly what type of man is wanted. A manufacturer would not be able to do that, speaking generally. Let us take a hypothetical case. A manufacturer wishes to work up a method of making a new dye. He submits his problem to the institute. We find it does not conflict with any investigation in opera-

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tion, and we accept it. The agreement is entered into for the sum which we determine. For work of this kind it would take a man with a salary of at least $3,000 a year, a man of considerable training, and of course we advise each donor to get the best man he can, to pay as much money as is necessary to secure the highest type of research chemist or engineer, and the donor always leaves it to us to decide upon the type of man, and also to select the man. In fact, we will take no investigation under any other conditions.

Mr. THOMPSON: I do not think I have made myself quite clear yet. Take a hypothetical case. The manufacturer asks for a man and you select one, and you pay $3,500 a year to him. The manufacturer agrees to pay that sum for one year. That is the minimum.

Mr. HAMOR: Yes.

Mr. THOMPSON: He may agree to pay that for four or five years, may he not?

Mr. HAMOR: Our investigations last from one to two years, and beginning a piece of work we will generally accept it for one year, and if it is an industry where there are constantly a number of problems coming up, we will take it for two years. We have several in operation for two year periods. Is that an answer to your question?

Mr. THOMPSON: Not quite. I understand you have a permanent income of $60,000.

Mr. HAMOR: Yes.

Mr. THOMPSON: And the balance of the income, $250,000 comes from fellowships?

Mr. HAMOR: Yes.

Mr. THOMPSON: How are you assured of continuing an income of that sort if the fellowships only last one or two years? Do I make myself clear?

Mr. HAMOR: We have a waiting list for one thing, five or six firms who want to put in fellowships, and most of the companies that establish industrial fellowships at the institute renew the fellowships year after year. If we show that we make good on an industrial investigation, the donor thereof is so impressed that he renews the followship and gives us other problems to work out.

Mr. THOMPSON: That is the problem I wanted to get at, as to the continuing of the revenue.

Mr. HAMOR: We could have a hundred fellowships if we had the room for them. There would be no trouble about it, because our manufacturers are awake to the realizable functions of research; they know that research properly executed pays, that chemistry is the intelligence department of industry, and that chemical research is the best agent for the extension of manufacture. For that reason they take the viewpoint that investigation, inquiry and research are the bases of progress in manufacturing, and we have no trouble about interesting people; in fact, they come to us and want to put in fellowships. We have had firms almost beg us to take fellowships from them, but we could not do it, owing to lack of space.

The CHAIRMAN: Do you do anything in the way of helping the formation of associations? You have spoken of the Laundrymen's Association and this big bread company. Does the Institute issue any propaganda, or do the trades form associations so as to be able to donate the fellowships?

Mr. HAMOR: Not directly. We play some part in the stimulation of association work. That is, we have shown that a small company, which could not afford to spend three or four thousand dollars a year in research work, if joined with other companies in similar lines of business, could contribute several hundreds and the association could then put in a fellowship, and each company member would profit therefrom.

The CHAIRMAN: We are starting at the beginning. We would like to know just what are the first steps to make this successful. As you say, you make good, and the

men come to you. The question is what are the first steps to take to interest industries throughout the country?

Mr. HAMOR: It requires an extensive round of dignified publicity; journal articles showing the value of research, addresses before associations and groups of manufacturers, interesting them in research, and the careful distribution of literature.

The CHAIRMAN: Have you anything to do with the marketing of the product which is the result of your discovery and research? For instance, as to insecticides, what do you say.

Mr. HAMOR: Dr. Hedenberg's work on insecticides will be eventually finished and he will be taken over by the company, if he desires, and put in charge of the manufacturing department. He is now developing the processes and finishing his research work. The Institute advises on marketing products developed for donors, but does not participate in actually selling these products.

The CHAIRMAN: Can you work out from the start the various steps you have taken in your research? You spoke of a unit plant. You have the Institute, but you go further and actually erect nearby a complete factory to prove up. Could you give shortly the various steps which are taken by the Institute?

Mr. HAMOR: Immediately after the appointment of the incumbent of a fellowship, his first work generally is bibliographical, making a study of the literature in order to familiarize himself with the problem. He then goes to the plant of the donor, and spends some time there, usually a week or two, depending entirely upon the complexity of the different problems. He returns to the Institute, equips his laboratory, and starts work. He orders in the special apparatus that he needs. At the conclusion of the laboratory work—it is sometimes termed research on the test tube scale—we put up a unit plant and study the economics of the process developed. It is usually done at the Institute but sometimes at the plant of the donor interested. The Fellowship works out the economics of the process, and if he shows it to be profitable on a unit scale, the company takes it up and makes a large scale installation.

The CHAIRMAN: Where do you yet your men?

Mr. HAMOR: That is our biggest problem. At first we went out to the universities for men, but gradually, as our work came to be better known, and the positions became more attractive, we got a line of applicants, and we have, speaking on the average, from 100 to 150 select applications on file all the time. Our positions are attractive in that they offer good opportunities for productive research and, upon the successful completion of the fellowship work, a permanent position with the donating company.

Mr. THOMPSON: How long has your Institute been operating?

Mr. HAMOR: Since 1911. From 1907 to 1911 the system was in operation at the University of Kansas, and in 1911 it was transferred to the University of Pittsburgh.

The CHAIRMAN: In 1915, you got into your present premises?

Mr. HAMOR: Yes, in 1915 we moved into our permanent building. We had passed out of the experimental stage. Up to that time the system had been operated in a demonstrational way. It had been in the adolescent stage up to the time we moved into the new premises.

Mr. THOMPSON: Could you give us an approximate idea of the amount of money involved in the establishment of the Institute at the University of Pittsburg and now as you have developed it?

Mr. HAMOR: At the University of Kansas, the first Fellowships were on laundering and bread-making. They had six or eight Industrial Fellowships in operation when Dr. Duncan came to Pittsburgh. In September, 1912, we had eleven Fellow-

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ships in operation, and when we moved into the new building, twenty-three. At the present time we have forty-seven.

Mr. THOMPSON: How much money do your plant and buildings represent at the present time?

Mr. HAMOR: Our building and equipment cost about $350,000.

Mr. THOMPSON: The present buildings?

Mr. HAMOR: Yes. The first building cost $10,000. It was a frame building, which is still standing. That was a building put up in 1911 for the department of Industrial Research at the University of Pittsburgh.

Mr. THOMPSON: It cost $10,000?

Mr. HAMOR: Yes.

Mr. THOMPSON: And your building to-day cost what?

Mr. HAMOR: $350,000.

Mr. THOMPSON: And equipment?

Mr. HAMOR: That cost includes our permanent equipment.

The CHAIRMAN: Was that donated by the Mellons?

Mr. HAMOR: Yes, the building was erected through the generosity of Messrs. Mellon, and in addition they have provided a foundation which gives us an income at the present time of $60,000 a year.

Mr. THOMPSON: What was the original endowment?

Mr. HAMOR: It was not endowed up to the time our building was erected. When Dr. Duncan accepted the professorship of industrial chemistry at the University of Pittsburgh, the University paid his salary and erected the first building, which cost $10,000, and maintained it itself. In 1913, Dr. Duncan interested the Messrs. Mellon in the Industrial Fellowship system, and they donated the money for the erection of a permanent building. Upon going into the new buildings, and getting everything organized on the present basis, they assured us of their support.

Mr. THOMPSON: That is to say, they gave $350,000 for the buildings and equipment, and an endowment besides.

Mr. HAMOR: Yes, we ask for an annual appropriation and this they furnished us. For the past two years, our administrative appropriation has averaged $60,000 which has been provided by the Messrs. Mellon.

Mr. THOMPSON: Did the Mellons pay this money, or have they a fund invested in that particular Institute from which they could draw? I want to get the basis on which this Institute is financed.

Mr. HAMOR: The Messrs. Mellon pay this money. I referred to it as an endowment fund because it is equivalent to that, but it is actually an annual appropriation. We have our own board of trustees to administer the Institute, but the money is provided by the Messrs. Mellon. We ask for the money and they provide it. For instance, we intend to enlarge the institute, to complete a fifth floor, and we will get an additional appropriation for it.

The CHAIRMAN: What I think Dr. Thompson is trying to get is, have the Messrs. Mellon set aside say a million and a half dollars, the income of which is devoted to your purpose, or is it simply an annual gift of the amount which you and they consider necessary to run the institute?

Mr. HAMOR: It is an annual gift.

The CHAIRMAN: Something has been said by previous witnessess about this bread Fellowship and a question was asked about the quality of the bread. It is not very important perhaps, but I suppose you can speak as to the quality of the product.

Mr. HAMOR: The bread is of the very highest quality; in fact, speaking from a biochemical standpoint, it is in every respect a good product.

The CHAIRMAN: What is the name of the company, if it is fair to ask.

Mr. HAMOR: As a usual thing, we are not privileged to give the names of donors, but I do not mind telling you in this case. It is the Ward Baking Company of New York, with branches in the large American cities.

Mr. THOMPSON: How many men have you in the Institute, independent of those Fellowship men?

Mr. HAMOR: You mean in addition to the Fellows?

Mr. THOMPSON: I understand that the Fellows are paid. You do not finance the Fellows?

Mr. HAMOR: No.

Mr. THOMPSON: How many do you pay for?

Mr. HAMOR: We have six men on the administrative staff and we also pay the wages of the janitors, the engineers, stock room men, and office force.

Mr. THOMPSON: What I am trying to get at is how much money is it going to cost us to establish an institute in Canada analogous to the Mellon Institute.

Mr. HAMOR: I can tell you this, that to establish a large research laboratory costs $3,500 per year per research man. That is, a laboratory of the type of the Eastman Kodak Company or of the Mellon Institute. Your first cost would be $3,500 per man, and your maintenance charge would be $3,300 per year per man.

Mr. THOMPSON: I would like to know the minimum number of men that we would have to employ to start this thing here.

The CHAIRMAN: We propose to combine two functions, a Bureau of Standards and an institution like what we call the Mellon Institute.

Mr. HAMOR: Yes, I understand about that.

The CHAIRMAN: That is the problem that Dr. Thompson is asking about. What would be your minimum?

Mr. THOMPSON: Could you give us an approximate estimate of what we would require to establish in Canada a research institute, together with the equipment and the cost of maintaining it? That is really the practical problem that confronts us.

Mr. HAMOR: It seems to me that your building and equipment would require an expenditure of at least $500,000.

Mr. THOMPSON: Building and equipment?

Mr. HAMOR: Building and equipment $500,000? That would not include a very elaborate equipment because a physical testing equipment is quite expensive. The Bureau of Standards has probably furnished you with information about their equipment. A chemical and physical research laboratory, presuming it to be of the type of ours, would cost $500,000 at the present.

The CHAIRMAN: We have had no evidence from the Bureau of Standards yet, so that we are somewhat in the dark as regards that.

Mr. HAMOR: All I can say is that a chemical and physical research laboratory of the type of ours would cost at least $500,000 to erect and furnish.

The CHAIRMAN: Could you get that in operation with $60,000, independent of Fellowships altogether?

Mr. HAMOR: No, we could not. That $60,000 a year only defrays the administration expenses and the cost of maintenance and upkeep of the building.

The CHAIRMAN: Heat, light and power?

Mr. HAMOR: Yes; and the janitorial and office forces, the library, shop and so on.

The CHAIRMAN: You have given us a figure for establishing; would you venture on a figure for maintenance, independent of Fellowships.

Mr. HAMOR: $50,000 per year. You mean just for the operation of it? The administrative staff and upkeep of the building would cost about $50,000 a year.

Mr. THOMPSON: Whether we can go into the Fellowship business is another question. I understand that the Fellowships are a separate thing. The Fellowship branch of your work is self supporting?

Mr. HAMOR: Yes.

Mr. THOMPSON: We may or may not go into that, but if we establish a research laboratory, we shall have to have a permanent force of researchers, and therefore we shall have to provide an annual sum for that purpose.

Mr. HAMOR: You can figure on $3,300 per man per year. That is for ten, and above. It would be impossible for me to anticipate how many men you would have. Suffice it for me to say that for the maintenance of your building, and the salaries of the permanent staff, that is administration, would be $50,000. That should be adequate. For your laboratory staff $3,300 per man per year should be sufficient. That should defray not only the salaries, but also the cost of the apparatus. In other words, to maintain a laboratory of the type which you plan, it is our experience that it would cost $3,300 per year per man. That is for maintenance, and includes salaries and physical upkeep.

Mr. ROSS: That is a permanent investigating staff that you are talking about?

Mr. HAMOR: It does not make any difference whether it is permanent or not; it would be that per man per year, whether it would be under the Industrial Fellowship system or a Bureau of Standards plan.

Mr. THOMPSON: Is that $3,300 per man independent of the administrative staff?

Mr. HAMOR: Yes.

Mr. THOMPSON: Suppose you had a staff of ten researchers, you would require an administrative staff as well?

Mr. HAMOR: I have given you the figure for that.

Mr. THOMPSON: That is $50,000?

Mr. HAMOR: Yes, that is my opinion.

Mr. THOMPSON: Then your figures are $3,300 per man per year for the research staff and $50,000 for administration?

Mr. HAMOR: Yes. I think that is conservative for salaries and upkeep. I have discussed this subject with Dr. C. E. K. Mees, of the Eastman Kodak Company, and other leading industrial research directors, and they have given approximate figures which are practically the same as I am quoting.

The CHAIRMAN: It has been urged on us and elsewhere that in Canada it might be better to supplement the work of the universities throughout the country and enable them to carry on industrial scientific research, as well as research in pure fundamental science. Would you care to express an opinion as to that?

Mr. HAMOR: I am familiar with that aspect of your work, and I think there are certain problems that can be more advantageously attacked in the university, that is through the means advanced from the central organization. For instance, an investigation, let us say of oil shale in New Brunswick could perhaps be better carried out at an experimental station in connection with the University of New Brunswick. There you would have the material at first hand, and the opportunity to study the various economic and physiographic conditions which have to be considered in found-

ing an industry. The same statement applies, of course, to the development of the tar sands of Athabaska."

The CHAIRMAN: That might be maintained by a grant.

Mr. HAMOR: An appropriation.

The CHAIRMAN: But the suggestion went a little further than that. While we might establish a Bureau of Standards here, it was suggested that perhaps it would be wiser not to annex to that a Mellon Institute, if I might put it that way, but rather to see that the various universities are so equipped and financed that they could each be an independent unit similar to the Mellon Institute. Have you considered that aspect of the question?

Mr. HAMOR: Yes, I have. That is practically, as I understand it, the British plan, the plan that has been followed in England; I mean as regards the non-operation of the central institution, like the Mellon Institute, but the distribution of research to different institutions by means of appropriations.

Dr. MACALLUM: These guilds in the vast majority of cases provide their own laboratories. A few, two or three, have placed their research staffs in the university, for instance, in the University of Sheffield. The dye industry has placed its research staffs in that university. But the guilds are supposed to directly maintain their own laboratories.

Mr. HAMOR: Those are distinct laboratories.

Dr. MACALLUM: Some of ours are placed in the National Physical Laboratories.

Mr. HAMOR: I think that research is so urgently needed in Canada that it would be well to start by distributing it to universities that are best equipped for handling it, and then begin this central institution.

Mr. MCGIBBON: Do you think that would be as well as one authority here and one directing mind?

Mr. HAMOR: Of course, there would be one directing mind, for the central committee, or the council, as I understand it, would make these assignments to the institution, but I do not see why research could not be commenced immediately at the universities. You would not only be training men there for the institute, but you would be actually doing something and getting the work under way.

Mr. MCGIBBON: Supposing you have so much money for scientific research work, and you divide that up between fifteen and twenty universities and put them all on industrial research, that would be one method, and another would be to have a central director, and have all the work under his control, instead of fifteen or twenty directing minds.

Mr. HAMOR: I think that would be a thing to aim for, and have a central institution by all means, but I alluded to the initiation of work at the present time by encouragement of industrial scholarships in educational institutions, which could of course be carried out along with the central organization, because you have to look to the universities to feed you with qualified research men.

The CHAIRMAN: You said you had 150 applicants.

Mr. HAMOR: We usually have about that many.

The CHAIRMAN: Are they university men?

Mr. HAMOR: All of them. Most of them are men who have their doctors' degree, or an equivalent.

Dr. MACALLUM: They have all been trained in mental research.

Mr. HAMOR: Yes; they are more or less proficient in research methods before we take them on, and quite a few of them are experts in certain lines of work.

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Mr. McGIBBON: You would not think of taking a man on for research work who had not been trained in this way.

Mr. HAMOR: No. But I would like you to understand that we do experience difficulty in obtaining the right sort of men, especially experts. For instance, we are looking for two ceramic engineers and we cannot get the desired type at present.

Mr. McGIBBON: Is that not a difficulty the world is up against always? Getting the right sort of men?

Mr. HAMOR: Yes. That is the biggest problem in the operation of a research institution, getting the men. The selection of a director is itself a big proposition. The director's first difficulty is in surrounding himself with a competent advisory staff, and after doing that to select the researchers is the biggest problem of all—to get the right type of men.

Mr. ROSS: There are two forms of research in the Mellon Institute, are there? There is the research that they undertake themselves and the research they undertake for certain industries. Is there not research carried on by the Mellon Institute off your own bat, and then research submitted by different guilds or industries for which they pay something?

Mr. HAMOR: Practically all our work is industrial research on an industrial fellowship basis. Members of the staff, for instance, do occasional research work, and with the exception of those members of the staff, there is no other research work carried on in the institution, except for the donors of fellowships. When a man is appointed on an industrial fellowship, he agrees to devote the whole of his time and thought to the interests of his fellowship. You see the donor of a fellowship enters into a definite agreement with us, and we enter into a definite agreement with the man whom we select as the incumbent of the fellowship, and according to that agreement he can do nothing else. There may be by-paths come up in connection with his research, and he will publish the result with the permission of the donor. For instance, in carrying out some work they may determine some new constituents in an organic body, and with the permission of the donor a report may be published, but he devotes all his time to the interest of the fellowship.

Mr. ROSS: On that one subject?

Mr. HAMOR: Yes. The members of the staff carry out a certain amount of research work. Dr. Bacon, for instance, has several assistants who are students for advanced degrees. They are pursuing graduate work under Dr. Bacon's supervision, and also looking after his private researches which he is carrying out on lines in which he is interested.

Mr. ROSS: Is there any differentiation made in the results of the research, supposing your own staff make a discovery? I imagine that would be for the public. But supposing the fellowship makes a discovery, does the donor alone get the benefit of that?

Mr. HAMOR: Yes, the donor of the fellowship. All results obtained belong exclusively to the donor. But three years after the expiration of the fellowship we reserve the right to publish the results, providing they do not injure the rights of the donor.

Mr. ROSS: How long, under the American law, has the donor the right to this?

Mr. HAMOR: We turn over results entirely to him, and they become his personal property, and he is entitled to them, because he is the man who takes the chance and makes the investment.

Mr. ROSS: And he has to go through the usual form of obtaining a patent.

Mr. HAMOR: Almost invariably the processes are worked out and patented, and assigned by the fellow to the donor. The applications are made in the name of the

fellow, and he makes an assignment to the donor of the fellowship. In other words, he has no interest in the patent, but in certain cases, on certain fellowships, they give bonuses or interests in the processes.

The CHAIRMAN: That is either a matter of voluntary gift or arrangement at the time.

Mr. HAMOR: It is usually a previous arrangement, but last year, on account of work carried out by some of the men, they did give large bonuses voluntarily.

The CHAIRMAN: I do not understand the situation from a commercial or financial standpoint. After three years you have the right to publish to the world so long as it does not injure the donor.

Mr. HAMOR: Assume that the donor has made a big investment in plant and has carried on the process, he might be injured if the details of the process, particularly the economic details, were published. Of course, in a case like that we discuss it with him and almost invariably abide by his decision. I may say that every donor is perfectly liberal. Manufacturers are becoming increasingly keen to advance the interests of science. They give information wherever it is possible.

Mr. ROSS: If this was a publicly endowed institution, I could understand it, but I do not see how the system adopted by the Mellon Institute can be adopted for the people of this country.

The CHAIRMAN: That is what Dr. Thompson was trying to get at, whether it would be better to have Fellowships donated, or whether the country would bear the greater part of the cost of these specific investigations into industrial problems.

Mr. HAMOR: Your station would be much the same as the engineering experiment stations that have been projected in the United States; that is to say, industrial experimental stations somewhat of the same type as the agricultural stations, only carrying out investigations for industrial concerns, with everything public and made available. That is a closer analogy than is the Mellon Institute. The Mellon Institute, so far as the publication and distribution of information is concerned, has taken a lead. I do not think that can be urged as a criticism against the system. Since our foundation, we have averaged twenty reports of researches per annum.

Mr. ROSS: I am not finding fault with the system.

Mr. HAMOR: You want to know how it would go here.

Mr. ROSS: Yes. Yours is a privately endowed institution. You do not get any money from the State?

Mr. HAMOR: Not at all.

The CHAIRMAN: Let us suppose that one of these donors secured a valuable discovery, and patented it, but made no use of it at all, what attitude does the Institute take?

Mr. HAMOR: That would be something for the donor's own determination; we would have nothing to do with it.

The CHAIRMAN: But if after the lapse of three years it was found that he had not used it?

Mr. HAMOR: We would prevail upon him to make it available. The process becomes his personal property.

Mr. THOMPSON: He pays for it.

Mr. ROSS: That may be alright in their institute, but we cannot spend public money in that way.

Dr. MACALLUM: If all the firms in an industry were engaged in contributing to a Fellowship, what then?

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Mr. HAMOR: That is the advantage of this system of guild Fellowships. Let us take a case. We have one on magnesia insulation. This association is made up of five or six companies, and the researches which we carry out are supervised by a committee appointed from the members of the association. That is, this committee collaborates with the Institute in carrying out research, and all discoveries made are presented to each company member of the association. If one company does not adopt our improvements, that company falls behind. Of course, the adoption of any discovery that we make is usually general by the company members.

Mr. ROSS: In that case, would the members of that association alone be entitled to the advantages of whatever patents they obtain for the discoveries made?

Mr. HAMOR: Yes.

Mr. ROSS: You might make an arrangement in this country, or generally, in regard to all guilds that in case of a donor making a discovery of value he should have the exclusive use only for a very limited term, and then it might become public property, the time allowed being shorter than that granted under the patent laws.

The CHAIRMAN: It is in my mind that there was such an arrangement in Great Britain, or some other country; there was a limited use.

Dr. MACALLUM: The trade associations for research receive grants. There is a department for scientific and industrial research in Great Britain, and these associations must not take out patents without advising the department. They are, of course, all the firms in a certain line of industry.

Mr. ROSS: They can all use it?

Dr. MACALLUM: Yes.

Mr. ROSS: And anybody can take out a patent?

Dr. MACALLUM: The patent may be taken out if the department of scientific and industrial research so advises or permits. The department gives a certain grant to aid the particular association, and the department preserves its right to say whether a patent can be taken out.

Mr. HAMOR: We do that at the Institute. The decision rests entirely with the administration of the Institute as to whether any process developed is patented or not.

Mr. ROSS: Irrespective of what the donor wishes?

Mr. HAMOR: The donor leaves that entirely to us. For instance, we have developed a number of processes which we think it may be more advantageous to operate in secret rather than to patent them. That is particularly true of our war work.

Mr. ROSS: The donor himself can operate that?

Mr. HAMOR: As a secret process rather than as a patent.

Mr. ROSS: That is bad. If there is any good idea developed we should get the benefit of it.

The CHAIRMAN: In relation to several of those large laboratories established in your country, they make from time to time most valuable discoveries. They either keep them secret, or take out patents. The result is the same. But they are laid by for years to come. The manufacturers may not want to change their machinery or their mode of operation, or the market conditions. As a matter of fact, the world is not enriched for an indefinite time because of these discoveries.

Mr. HAMOR: That statement is perfectly true.

Mr. MCGIBBON: What would you suggest to avoid such a condition of affairs, because I think it is, on the face of it, very unfair and unjust. That is one of the problems we have before us.

Mr. HAMOR: In the case of those company laboratories, they have a right to do that; that is their privilege. It is an unfortunate condition, but it all depends upon

the spirit of the man back of the operation of that laboratory, and the spirit of the executives and officials of the company. For instance, the General Electric Company and the Eastman Kodak Company have published research results and papers constantly. If you take up a number of the journal of the Franklin Institute, you will find papers from the Eastman Kodak Company. They run a section in the journal, which is a monthly publication. Certain of the work of the General Electric Company —you all know of Dr. Lang Muir's work—has been published.

Dr. MACALLUM: That is on pure science, not on the industrial side.

Mr. HAMOR: On the industrial side, they do keep most of it secret.

Mr. SHEARD: In your judgment, is it not fair that the fellow who makes an important discovery should have some financial interest in and derive some benefit from the discovery upon which he has worked probably two or three years?

Mr. HAMOR: Usually, if a problem is one which upon solution proves very important economically, a bonus clause is provided in the agreement. For instance, Dr. Kohman, who developed the Arkady yeast food received a bonus of $10,000 on solving that problem, and he has received another bonus of $10,000 from the same company. One of our petroleum fellows received a bonus of $10,000 for getting up a process of cracking oil; and Dr. Vogt, who developed the dental cement, receives a royalty from the sales on that product. It all depends on the importance of the problem solved. We have another case in the Fellowship on asphalt roofing material. The fellow made such improvements that the company voluntarily gave him a bonus of $500 without being asked. Of course, if a man makes good he has a permanent connection with the company, either separately at the Institute, carrying on research, or with the company in a research position.

The CHAIRMAN: Supposing he had two or three lines of work which he was following up—one discovery leads to another—he might want to continue his work, the different lines being co-related to that industry?

Mr. HAMOR: He could stay on at the Institute if he was a good research man. We provide for a man's staying on who is doing brilliant research work. We have some men who have been with us for twelve years, men who came from Kansas with Dr. Duncan, and stayed on. They are men who would not go into the factory. They have made good in laboratory research, and they have not the personality to make good as industrial executives in a plant. They are born research men, and research genius is often of that type.

Mr. MCGIBBON: How are these men paid?

Mr. HAMOR: Our salaries range from $1,200 to about $5,000 a year, and the average salary of an industrial fellow might be stated as $3,000 a year. That would be a fairly good average.

Dr. MACALLUM: Do you not think that it would be economical and practicable to include in the National Research Institute proposed here provision for research along the industrial lines for guilds.

Mr. HAMOR: Yes, I do. I am strongly in favour of it, because it seems to me that your manufacturers could be guilded, if I may use that word, and formed into associations. For instance, you could get all the brick manufacturers and the refractory manufacturers together. They would come together; at least the important and progressive ones would, and eventually the others would follow their lead. In that case, all the information would be public, and would be made available immediately. You would not be working for one firm. If one firm wants to carry out research, it could endow an industrial scholarship at McGill or Toronto University, or Queen's, or at whatever university has the best facilities for the purpose. It seems to me that your association should be primarily concerned with guild or association work. In that

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way you would be open to no criticism, and instead of serving one company as a university might do, you would be serving a big group of the leading firms in the country.

Mr. McGibbon: There is one point which might assist us here in the way of argument. Can you give us one or more instances of the value of the discoveries that have been made?

Mr. Hamor: Yes, I could give you quite a number, but it is difficult to supply the economic data which is so desirable for that purpose. With the exception of the yeast food proposition, I am unable to give you any figures as to what saving was effected. The accomplishments of research form a big story. Some of our most important work at the Institute has been in petroleum; that is in the methods of cracking oil to produce gasolene; and in the improvement of processes in the hydro-metallurgy of copper, particularly the utilization of low grade copper ores. In that connection, there was the development of the Weidlein sulphur dioxide process, which has been found to be of advantage at our plant in Nevada; the working out of new flotation agents for the flotation of low grade ores; the development of a process for concentrating coal by the application of flotation principles; the utilization of washer-waste, coke breeze, and other low grade fuels; the improvement and development of the Koppers by-product coke oven which is used by 90 per cent of the people in the States, the development of new motor fuels like benzol which is now being used mixed with natural gas gasolene; the discovery of dental cement; the improvement of bituminous roofing materials, especially combinations for industrial buildings; the discovery of methods of manufacturing various dyes, and chemicals formerly imported from Germany, processes for which we have worked out during the last four or five years. There is an endless number of these. Then there is the improvement of all the processes in the laundry industry, and in that connection the investigation of soaps. The discovery of colours necessary for the manufacture of inks formerly imported from abroad, presented quite a big problem, because there is over a million of gallons of ink used in the United States per annum. There was the standardization of magnesia insulation, the drawing up of standard specifications, and improving of the manufacture of products along various lines; the same thing for asbestos; the systematic study of leather belting, something that had never been carried out before; the study of the relative value of composition soling; the discovery of a new process for the production of sulphuric acid. You see platinum is a metal which is usually employed, and we found a material which is very much cheaper and had a longer life, and that constitutes the basis of a new fertilizer process. Sulphuric acid is the principal agent in the production of phosphate. The production of pure hydro-carbons of the type of acetylene, ethylene and other things have increased and we find new uses for them—the preparation of products therefrom, and so on. And so it goes on in almost endless variety. I have had many people ask me about the instances where great economies had been effected through the agency of research, and of course if you do not mind about my being a little general, I could refer to great chemical discoveries and accomplishments of research in the United States. Perhaps the best illustrations of what chemists have done in the improvement of industrial processes is to be found in the list of recipients of the Perkin Medal. Each year the New York Section of the British Society of Chemical Industry gives a medal in honour of William H. Perkin to reward the chemist who has made the greatest achievement in industrial chemistry, and among those recipients have been Charles M. Hall, who discovered the process used by the Aluminum Company of America for the electrolysis of aluminum oxide; J. B. F. Herreshoff, who discovered the furnace which bears his name and which is widely used in the copper industry in the United States; Leo. F. Baelseland, who discovered balselite, which is a combination of phenol and formaldehyde, and also discovered velox paper, and thus made photography popular; Arno Baer who developed the corn products industry, an enormous manufacture in the

[W. A. Hamor.]

United States. Then Herman Frasch, who not only discovered a method of getting sulphur from the Louisiana deposits but also found a process which was purchased and adopted by the Standard Oil Company for removing sulphur from petroleum. The Gulf States sulphur deposits are rather interesting. They occur about 800 feet below the surface, ranging from four to eight hundred, but in Texas and Louisiana the principal one are eight hundred feet. They run down steam and air and force up the molten liquid sulphur, which is run into bins and solidified, and that sulphur occurs in strata which are 20 feet or more deep.

The CHAIRMAN: They produce it at one cent a pound.

Mr. HAMOR: Yes, sulphur is worth a cent a pound, twenty dollars a short ton, and that is one of the big problems, finding new uses for sulphur, because there are such enormous quantities of it available. Then we have James Gayley, who discovered the dry blast, which effected such great economies in the steel industry. The big improvements that have been made in industrial practice, particularly in the last 25 years, have been chemical improvements. Mechanical improvements have been made constantly, but the striking improvements have all been the result of chemical research. I have written some papers dealing with the subject. I have sent copies to Dr. Macallum. It is the big story about the growth of the appreciation of research in the United States. Our big laboratories, like the Dupont laboratories at Wilmington, the General Electric laboratories, the Eastman Kodak Company's laboratories, Armour and Company at Chicago, with their varied interests, and others have done great work. The large chemical companies have increased from four to six hundred per cent in the last three years in laboratory personnel—of course, along with that, accommodation for research. //

Mr. MCGIBBON: Could we get copies of your papers?

Mr. HAMOR: I could not send all of them, because most of them are out of print. I would be very glad to give you a list of the articles. They are nearly all journal contributions. With the exception of Dr. Duncan's books, which of course we have never revised, the literature of our own staff and of other directors of industrial research have been published in the journals of the American Chemical Society. Dr. Mees of the Eastman Kodak Company has in preparation a book on industrial research. I am only sorry that this subject presents such a vast field, and so many questions come up that you cannot make a very connected account.

The CHAIRMAN: Mr. Murray of the Canadian Manufacturers' Association is present and will address the Committee.

GILBERT M. MURRAY appeared before the Committee.

The CHAIRMAN: If you have any statement to make, our procedure has been that the witness shall make the statement and questions follow.

Mr. MURRAY: I feel a great deal of diffidence in appearing as a witness before this Committee after a gentleman who has given you so much valuable information right on the point, as Mr. Hamor has. I presume, however, that there are certain things that are wanted for the purpose of the record, and it may be of value, therefore, for you to know that the Canadian Manufacturers' Association, for whom I speak to-day, are unqualifiedly in favour of the policy of very liberal financial support for the purpose of advancing the cause of industrial research. Our resolutions upon that subject can easily be secured and filed with you for the purpose of the record if you desire.

The CHAIRMAN: We have them.

Mr. MURRAY: I might add that at a recent conference between the representatives of the Manufacturers' Association and organized labour, another resolution was adopted and transmitted to the Government in support of this same very worthy work.

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Some ideas occurred to me while listening to Mr. Hamor's evidence, which I know I can offer with the full approval of the Manufacturers' Association, and which may perhaps clarify some points with regard to which there seems to be a little doubt. The manufacturers of Canada have long been organized to a somewhat limited extent into what might be called guilds or trade sections, trade organizations; and the tendency of recent years has been to progress along that line much more rapidly. I think perhaps that an incentive to such progress has been provided by the exigencies of the war, but the fact remains that in this country we are now being organized either in affiliation with the Canadian Manufacturers' Association or independent of it. There is a large number of societies which are concerned with the problems peculiar to one line of industry, so that it seems to me that the foundation is there laid for a very hearty measure of co-operation between manufacturers as organized in those guilds and the research institute, the establishment of which is under discussion. These organizations, of course, have been formed primarily for purposes other than research, though as they get more closely together and understand the problems more fully and more sympathetically, there will be a notable tendency to make progress along one of the lines that is contemplated in the resolution which this committee is considering. I refer particularly to the development of standards. If I am correctly informed the proposition is to combine with this research institute a bureau of standards. The incentive moving manufacturers, who are practical business men, towards this question of standardization of products is to some extent a matter of economical production, the reduction of overhead expenses, and the saving of the consumer from unnecessary confusion. I might perhaps illustrate by pointing to something which was accomplished long before the war, that is, the arrival at a standard specification for Portland cement among the manufacturers of this country. I refer, of course, to a period antedating the cement merger, because there was a time when we had perhaps twenty different companies manufacturing Portland cement in Canada. In the absence of any standard of cement, these people went out to sell their goods in a manner that confused the purchaser. There was, of course, an opportunity for great resourcefulness on the part of the salesmen, but so far as the purchaser was concerned it only gave rise to confusion, and frequently it was found that in the absence of any uniformity of specification on the part of the Canadian mills, preference was given in large public works to a cement of a standard specification imported from another country.

I might illustrate again from the experience of the manufacturers of furniture. You have here a desk which is finished in what I think would be called golden oak. The finish of that desk is arrived at by a series of stains and varnishes, with varying degrees of rubbing, and various applications, sometimes two and sometimes three alternately, sometimes not alternately. The fact remains that if you were to purchase a piece of furniture of the golden oak finish made by a Canadian manufacturer five years ago, and another piece of furniture, presumably of the same finish made in the same factory, you would probably find a lack of uniformity in the finish. There would be a difference, and to the householder that means a great deal, because the woman who presides over the house is frequently called upon to match furniture. She goes back to the same store, and if she is careful she will inquire whether the article is made by the same company. Her doubts are set at rest and she passes out of the store only to find when she reaches home that there is a slight difference. It does not exactly match. If there are these variations between the products of one manufacturer at different times, how much more likely are they to occur as between the products of different manufacturers at different times. Consequently the furniture manufacturers got together and began to consider the question of standard furniture. Taking the oak, we have the golden oak, the weathered oak, the cathedral oak, and many others. I am not going to follow that through. I merely give that as an illus-

tration showing the tendency for standardization that existed even before the war, and upon which the manufacturers are concentrating with more energy than ever at the present time.

It finds illustration in another way with regard to those classes of goods which are subject to variation in pattern and design. Take for instance boots. I was talking to a manufacturer the other day. He operates only a small factory and makes only men's boots, and yet he is producing thirty-eight different lines of boots, irrespective of the sizes in each particular line. There is a boot with a solid leather sole; a boot with a softer sole, a boot with a solid leather heel, a boot with a rubber heel, a boot with patent leather sides, and box calf tops, and so on it goes, to say nothing of the enormous variety of lasts which has to be employed to make boots of different patterns. It has occurred to them that there is an unnecessary diversity of styles, and so long as they all continue to produce in those various styles, they lock up an enormous amount of money in lasts. If by means of getting together and adopting more uniform standards they can eliminate these overhead expenses, it will benefit the manufacturer because by producing large quantities of boots of more uniform design he can get his price lower, and the consumer will get the advantage. There is a constant tendency along that line to-day, and that is the reason why the Canadian Manufacturers' Association views with a great deal of satisfaction the proposal to establish a bureau of standards in connection with the bureau of research. Possibly the illustrations I have employed would hardly rise to the dignity of the operations which Dr. Macallum has in mind, or to the standards which he would concern himself with; but at any rate they can be readily appreciated by the lay mind. There are some thoughtless people in Canada, who, believing there is no international boundry line in science, have been content to let Canada profit by the results of research in other countries. But that is an exceedingly inadvised course, it seems to me, for Canada to adopt, for the simple reason that in this country we have a great many resources which are more or less peculiar to this country, at any rate in the form in which nature provides them; and if we rest upon our oars, and await the progress of research in other countries it means that the development of our own natural resources will be very unnecessarily delayed. I need only refer to the work in which the Research Council interested itself in connection with the development of lignite in the West to illustrate what I mean in that regard. We have a great many resources of the kind in Canada which can and should be developed. But research, of some form or other, is a necessary pre-requisite of their development. Apart from placing the association on record as in favour of the establishment of this institute of dual capacity, my instruction from the Association is to say a word in regard to the advisability of concentrating upon one central research as against the spreading of energies over the universities. I cannot speak, of course, nor would the Association profess to speak, from the standpoint of the trained scientist, because after all that is out of our field, but from the standpoint of a business proposition, which is the standpoint from which we look at it, we feel that the establishment of a central bureau is something that cannot be got away from. In the first place, we recognize that expert men in research work are very scarce, and if there is going to be competition among the universities all over Canada for these men, and if when secured their services are to be available only for the investigation of such work as is turned into that particular university, then there is going to be a great deal of capacity wasted, and furthermore, there are going to be some very important problems entrusted for solution to men of inferior capacity. Consequently, we think that with so few really good men available, the services of these men should be available for every peculiar national problem that comes along.

In the second place, we think as business men that there would be an unnecessary duplication of plant and equipment if the work were parcelled out among the universities, without any central bureau. Every problem that comes up, or at least a great many problems that come up, will require special apparatus, and it is quite

conceivable that under a plan of distributing this work among the universities, two or perhaps three universities may be investigating the same problem, or at any rate, kindred problems at the same time, and piling up the cost for equipment which one set of equipment in a central bureau could handle.

In the third place, and we feel very strongly upon this point, we think that all research work is more or less inter-related. The research in one department may not proceed very far before we find that to get the results to follow things through to a conclusion, we have to initiate research perhaps in some other department. Let me illustrate that by reference to a specific commodity. Suppose, for instance, under a plan dividing the work among the universities, it was decided to avoid duplication by consolidating all investigations in rubber in McGill University, all investigations in textiles, in Toronto University, and so on. What are you going to do when it comes to investigating say automobile tires which combine textile and rubber? What will you do in the case of investigations which, when you get to the root of them involves some principle of colloidal chemistry which perhaps may affect investigations going on in half a dozen universities at the same time. We feel, therefore that with researches carried on in the Central Bureau under one directing mind with a staff under one roof, the results of one department can be quickly communicated to another department, thus saving unnecessary labour, unnecessary time, and so it will be all to the good. We do think it is possible that with a Central Bureau established, according as the administrators of the bureau acquire their experience, they will find that there are certain problems which may safely be left to the universities, and we would strongly favour utilizing the universities in so far as they can be utilized and in so far as the possibility of utilizing them is shown by the experience of the administrative staff of the Central Bureau. But to repeat, we feel that the Central Research Institute is indispensable, that our efforts should be consolidated on that in the first place, and that the handling of work by the universities may be allowed to proceed as circumstances would seem to justify.

There is another point that I think is worth mentioning; that is, that the foundation of successful research work is the ability of a research institute to command the services of men who have been trained in pure science. It is certainly the function of the universities to train men in pure science. I question whether it is the function of a research institute to train men in pure science, it would prefer to take these men that had been trained and utilize them in industrial avocations. But if any great amount of research work is turned over to the universities we fear there will be a tendency for men to be weaned away from the study of pure science to the application to industrial work; rather than the application of pure science first of all on account of the fact that there is more money in it, and consequently on account of that fact that he may be expected to open up a way to a more profitable occupation in connection with industrial concerns. Arising out of the evidence which Mr. Hamor gave and referring again to the question of these organizations of manufacturers it seems to me that one of the matters which seem to offer the best solution if we are to proceed in Canada along the lines of industrial development such as the Mellon Institute pursues would be overcome because of the struggle these trade associations or guilds in this country, I speak advisedly when I say that I know these associations would be glad to contribute to the support of fellows in the research institute. My reason for making that statement is that through the instrumentality of the Manufacturers' Association the Executive Committees of a number of these trade associations were consulted and they expressed their readiness to support such an institution and even in some lines of industry where there is no organization in existence, we secured promises from the leading firms in those industries to contribute towards a fund which would be a means of supporting industrial fellowships. Any beneficial result that may be secured by research in our institute would naturally be common

property to all those who contributed to funds and we feel therefore for that reason there would not be the same objection to having the fellowship largely supported by the State funds as there would be to fellowships supported in an institute privately endowed because I am quite sure in this country under the scheme I have outlined the public would be sufficiently protected and that the private employment of advantages arising out of discoveries would not be tolerated at all or at most for only a very short time. I think, gentlemen, this is a very imperfect statement, but if any of you would like to ask any further information I shall be glad to answer any questions.

The CHAIRMAN: It strikes me that it is a very important matter that has been opened up.

Mr. THOMPSON: I question whether if the Bureau of Standards established as you have it in mind, would standardize the industries, as Mr. Murray has referred to.

Mr. MURRAY: Possibly I did not make myself sufficiently clear. I could not conceive of course that it would be the function of the Bureau of Standards to take up a business at all, but I am impressed with this fact that at the present time there is legislation on the statute books of Canada which, and rightfully so, standardizes certain products when sold for export, for instance our beef when exported bears the stamp of the Canadian Food Board, and when your beef goes to the foreign market and there is upon it the official stamp of the Government of Canada to show that it has passed inspection, that the carcass was the carcass of a healthy animal, then it inspires confidence in that particular kind of product, and no doubt makes it more easy to sell that particular product. Our apples again are required to pass a certain inspection before being shipped abroad. Now the importance of some form of Government approval for standardizing these products and thereby affecting the sale of these products in the foreign markets cannot be overestimated.

Mr. THOMPSON: That is particularly true of food products.

Mr. MURRAY: Particularly of food products. Now I recall that before the war we bought an article which was manufactured in Edinburgh and the box in which it was put up bore a certificate from the Institute of Hygiene, I think it was, of the United Kingdom, certifying that the contents of this box were made from wholesome material, under inspection and so on. Inside the box there was a more lengthy explanation of all the principles of hygiene and the circumstances under which the manufacturers were allowed to use these labels. All that went far towards inspiring confidence in the consumer who once having used this article and found that it was satisfactory would have a tendency to always ask for the same food again. Now then, if by the request of the manufacturers, who themselves perhaps would be consulted in setting up the standard, this Bureau were to make or to authorize certain standards for Canada I believe it would be of tremendous advantage to us in our efforts to increase the export. Take, for instance, woollen goods, it should not be difficult having regard to the length of the staple and the admixture of cottons to standardize woollen goods with certain labels, which would be a tremendous advantage to the consumer in this country. I know I can go to certain shops in Ottawa to-day and I can get a suit of clothes that would have the appearnce of being splendid value but if I expose those clothes to a rainstorm probably a very large percentage of the weight of those clothes would disappear simply because the filling dust would be carried out by the water. Take a thread of that material from the hem and unravel it and you would get an idea of the length of the staple, and from that you would get an idea whether it was a woollen or a cotton thread. I was examining samples a few days ago and I found that the center of the yarn was pure cotton and around that wool had been woven or affixed to it by means of some adhesive. There was some short wool woven around the cotton cord that probably had been worn by many different people before, because at every process through which it goes the wool is shortened until this particular sample of wool was practically dust and was not more

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than one-eight of an inch in length and yet by some process that short staple was twisted around and made to appear like a good thread and when that particular material was exposed to a rain storm the water washes the short wool away and leaves nothing but the cotton thread. Would it not be possible by means of a Bureau of Standards to provide wool protection for the Canadian consumer, to provide some standard for woollen goods. I think it is possible and from my knowledge of the fact I am certain that material of that kind is not made in Canada at the present time, but is imported, and the general attractiveness of that material people are encouraged to buy it thinking they are getting full value, but they find out when they have worn it a very short time that they have been stung. I think under those circumstances that the establishing of a standard for woollen goods would be a perfectly legitimate function for this Bureau to discharge.

Mr. HAMOR: A strong movement in the United States, instigated by the National Commission, to have enacted legislation creating a standardization for textiles and we have the vigorous approbation at the present time of many great men among our fellowship which has just taken up the subject much along the lines that you have indicated here. It is one of many ways in which a Bureau of Standards could be of great use. The association of wholesale druggists and merchants has been somewhat backward in that respect in the United States and also the manufacturers of textiles but the legislation would be a good thing because the purchaser would be protected. Now there is still another way in which the association can be benefited by research and that is in the utilization of waste and by-products. Let us take, for instance, the tanning industry, to which you have referred. We have not utilized all the tallow, and the utilization of leather scraps or waste is another subject for consideration. One company began to investigate and they took up the utilization of cattle hair, that is an industry that has been more or less centralized, in order that it may be converted into a marketable form. Now that result has been obtained in the United States to-day. We have one company that handles and puts up from the tanneries 85 per cent of the cattle hair resulting from the depilation of the hide. And they have created a large number of new uses for that hair; for instance in textile work. It is used in the utilization of waste leather. A shoe company should study that subject. They found out in the United States that all this scrap leather could be taken up by one central company which could be organized just like any other organization, and they could convert this waste leather into fertilizers, because with appropriate treatment with sulphuric acid, you could make a very good fertilizer from leather scraps. You could very logically present that situation to him and give him a better insight into the conditions. I did not know of the number of guilds you had. I knew of your association but I did not know of the guilds. The spirit of these organizations is very encouraging and would give a central institution the very best kind of support and in fact secure its success from its inception.

Mr. MURRAY: I could give you one illustration along the line of utilizing waste material which is ripe for organization at the present time. In the Niagara district we have a great many wineries and in all the vats at these places there is a certain encrustation on the inside which is being absolutely wasted at the present time. The amount which any one winery would produce is hardly sufficient to justify that winery in putting up a plant for the utilization of that waste material, but if a process could be worked out and a company set up that would collect that encrustation from all the wineries there is no doubt they could make a very high grade of tartaric acid out of it, or perhaps something equally useful. Again, in the lobster canneries and the salmon canneries out in British Columbia, a tremendous waste is going on all the time of material which could be used for fertilizers and perhaps for various other purposes, and we have the salmon canneries of British Columbia very well organized. Similarly the lobster canneries of the Maritime Provinces are organized; so that there seems to be an organization in effect now, or a series of organizations in effect, which are simply

awaiting the establishment of something of this kind, in order to overwhelm them with problems, all of which could be worked out in the national interests without any desire to keep the results secret, which would add tremendously to our national wealth and indirectly benefit the consumers by lower prices.

Mr. HAMOR: We have one industrial fellowship in operation at the institute which is founded practically on Canadian associations. This particular manufacture has eight or ten plants, and it is operated in accordance with rules of an association, a co-operative association. The owners of the plant and the donor, upon our advice is ready at any time, upon the organization of this central institute, to take it from the Mellon Institute and place it in the central institute. He is a very patriotic man and in fact quite prominent in political affairs in Canada, and after discussing it with him we advised him strongly to do it, because he knows the conditions here, and you would be able to do the work just as well as we could; in fact you will be closer at hand and could do the work more effectively than we could. We received a letter from a canner in Manitoba, recently, wanting to put in a fellowship at the Mellon Institute, and we told him something about the plant in Canada, and advised him to wait, and said that he would have an opportunity of having his work done at home just as well if not better than we could do it at the institute. There is a keen interest among Canadian industrials in research, and they are waiting for the full realization of its value, and I do not think there will be any disregarding what you said. We have seen it and it is going to be a big success when it is started.

The Committee adjourned.

WEDNESDAY, June 11, 1919.

The committee met at 10.30 a.m., Mr. Cronyn, the Chairman, presiding.

The CHAIRMAN: We desire to have evidence from the representatives of the various scientific departments or branches of the Government on this question. We have Dr. Shutt, of the Experimental Farm; Professor Prince, Chairman of the Biological Board, and Dr. Saunders, the Dominion Cerealist.

Dr. Frank Shutt, of the Experimental Farm, will first address the committee.

Dr. SHUTT: I am here in response to your call, but I must confess to an ignorance of the exact nature of the subject or subjects upon which you wish me to give evidence, I shall, of course, be extremely happy to contribute anything in my power towards the deliberations of this committee, if you can indicate to me the phases or aspects of the question—which I presume is scientific research—upon which you would like me to speak.

The CHAIRMAN: We are here to inquire as to the desirability of aiding industrial scientific research in Canada and to discuss the best methods to adopt in furtherance of that aim. Although the order of reference is not perhaps as broad as was originally intended, we also, I take it, are asked to consider the question of the co-ordination of the various scientific departments now in existence with any other scientific institute which might be formed; in other words whether there can be such co-ordination, economically and properly adapted, or whether it is necessary to continue the separate departments of scientific research. Several departments have scientific branches.

Dr. SHUTT: I will endeavour to follow the outline you have given me and say a word or two on these several aspects of the matter, subsequently amplifying my remarks as may seem desirable to you.

[Dr. Shutt.]

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Taking first of all, the proposition of the Advisory Council for Scientific and Industrial Research, which has now assumed a definite and concrete form, I may say that I very heartily approve of the proposal to establish a National Research Institute, and for very many reasons. We have not in this country at present any establishment, university or laboratory to which problems needing research—chemical, physical or biological—can be referred, nor to which we can turn for the standardization of apparatus, materials, etc. This is something we have felt the want of for many years, and that feeling must become more and more keen as the years go by in the progress and development of Canadian industries. That is to say Canada needs a bureau or institute in which we can have our various physical standards determined. We are at the present time dependent upon other countries for work of this character and, apart from the fact that this is not a very dignified position for Canada to take, it is a very great inconvenience and a great detriment to progress in scientific work. I should perhaps be wrong in saying that we have absolutely no means in Canada of determining or investigating standards, but at any rate, those means are few and meagre and altogether insufficient, I am convinced, for the country and for the development of its Science and its Industries in the future. I believe the determination of physical standards is to be one of the principal functions if not the chief, of this National Research Institute. Then there is the question of the standardization of scientific apparatus. This is an important matter. We have at present no bureau in which thermometers, burettes and other instruments of precision used in absolute determinations, may be corrected and standardized. We are dependent on the Washington Bureau of Standards, or similar laboratories in other countries for this class of work. Every intelligent, educated man, I may say, not merely those who are scientific men, will appreciate the necessity for accurate apparatus and correct standards. This work is national in character and importance; the equipment and the specially trained scientific men to carry on this work must be provided for out of the National Treasury. May I repeat, this is a work of public and national importance. The institute, as I understand it, is to have another function. It is to be the means of promoting and undertaking research and investigations in connection with the manufactures and the industries of Canada. As an agricultural chemist, and one who has devoted his life to the studies of agricultural problems, I could not be expected to have detailed and intimate knowledge of Canadian industries but yet I know enough in regard to the manufactures of Canada to be aware that it is highly desirable, for the progress and welfare of this country, that some steps should be taken whereby many of the problems that are waiting to be solved should be attacked and solved. I think it is patent to every man conversant with the subject that, on the whole, our manufacturing processes in Canada are crude and wasteful. I am not saying anything derogatory to the intelligence of our people, but many of our industrial processes are on a very much lower plane, scientifically and economically, I think, than those of Europe, or even of the United States. //

//It is the same in agriculture as it is in the industries; the same in manufactures as in agriculture. I presume that every young country has to go through this rule-of-thumb, rough and ready, wasteful phase before it learns to be economic, but we have about reached that stage, it seems to me, in our history and development when we should take a step forward, improve our methods and utilize our waste by-products. Scientific research alone can do this. For some years I have been finding the need of greater attention to problems, relating to soil fertility, for instance. It is the same in the field of manufacture. There are processes of great value that have been worked out by some of our manufacturers, but there is still a large amount of work to do in that respect; and if we as a nation, are to compete successfully with the people south of the line and with our rivals in Europe, it seems to me that it is high time that provided the manufacturers will not take steps, the country should take steps to see to it that our processes are more economic, less wasteful. There is no necessity to go far

[Dr. Shutt.].

afield to cite examples. Nearly everything we have handled has been handled in a crude and wasteful way. Perhaps this has been inevitable owing to the exigencies, the necessities of the times; but what I am trying to emphasize is that we have reached the stage in our history when we must look more closely to it, and I do not think that the manufacturers unaided by science and by investigation on the part of men trained for the purpose will be able to do very much. That is another function of the Institute; it is I believe the most important function it will be called upon to perform.

In connection with the industries and manufactures there will be an opportunity for the many and varied natural resources of this country to be examined and investigated. A great deal has been said and rightly about the wealth of Canada in her natural resources, and I presume that there will be an opportunity for work to be done in that connection, although I am not certain as to the ways and means that have been proposed in which these particular problems will be dealt with.

With respect to agriculture, I may say that the problems in agriculture have to do with certain things, such as soils and plants and animals. They have to do with life, in its various forms and activities. The problems of agriculture are extremely complex in their nature. They are as a rule very difficult, and require patience and continuous and uninterrupted work. In these respects, of course, they are in certain aspects like the problems which will be attacked by the National Research Institute, if that institution is established and developed, as we hope it will be. But the point I am making is that many of the problems in agriculture require, to say the least, soils and plants and animals, and these, of course, cannot be found within the four walls of a chemical laboratory such as the institute will be in a measure, I presume, or a collection as it may be of laboratories. Consequently, the equipment and accommodation afforded by the Research Institute would not be such as to adequately provide for the conduct of a large number of agricultural problems, that is if I have correctly gauged the scope of the work of the Institute. I am pointing this out because, without consideration, one might think it would be possible for the Institute to at once take under its wing the conduct of our agricultural investigational work. That would not be possible, for there are so very many conflicting factors in agricultural investigations, not merely the different kinds of soil, and the different kinds of plant life, and the conditions affecting these, but even the weather conditions enter into it, making it absolutely necessary for much of our experimental work to be tried out, not only in the eastern provinces of Canada, but on the plains and in British Columbia. It is quite evident from the nature of the work, therefore, that it could not be confined to any one place, or merely in a building no matter how well equipped and manned, for scientific investigations. There are very many problems in agriculture which can be worked out, at any rate to a large extent, in the chemical, physical and biological laboratories such as would be established in the Institute, but the complementing work in connection with that must be done outside, because many of our investigations have what you might call an inside and an outside phase, a laboratory phase and a field phase. You can see that in connection with the determination of the ingredients of food stuffs, they must be analyzed in the laboratory, but they must be fed to the animals in properly equipped buildings for digestional investigations. The same things is true in regard to plant life. By our chemical analysis we may find a new material as a fertilizer, but it must be tried out in the field to obtain the results we seek as to its efficiency. Therefore, you will observe that for the proper conduct of agricultural investigational work we must have land and crops and animals. I may mention that I had suggested some years ago the establishment of an agricultural research institute for the prosecution of the more profound problems of agriculture. I am not going to make that suggestion this morning, because I am not sure that this is the time, the occasion, or the place to make it. The whole matter is a debateable one, one of complexity, because we have already an experimental farm system, established by the

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Dominion Government, which is very largely an investigational institution. I am not quite sure that in the minds of its founders it was to be entirely devoted to scientific investigation. I do not think it was. I myself have been associated with the system since its establishment more than thirty years ago, and it has always had other functions. Certain of these functions have developed to such a degree that the purely scientific investigational phase of its work in the several divisions has been to a certain extent overshadowed by other and important phases of the work. I refer to the matter of educational and advisory work, work sometimes of an elementary character, but nevertheless work which we found to our hand, work which has been extremely popular, and which, if we may judge from results, has been very successful. It will be evident to you that this educational, advisory, and demonstrational work is a different phase of work from that relating strictly to the investigation of scientific problems, but nevertheless it is a legitimate part of the Farm's work. Consequently, I do not think it would be right to consider or to judge the Dominion Experimental Farm system solely by its output in investigational work, though there is no doubt that it was intended at the outset, and it has been borne in mind by the larger number of its officers, that investigational work was its first and most important work. Nevertheless, as I say, and more particularly during later years and since the outbreak of the war, an analytical staff generally have devoted their efforts and energies to work other than strictly investigational and research work.

Mr. THOMPSON: Since they do investigational work, which system would you rather have; an enlargement of the laboratory system and of the research staff, or a central research bureau where certain phases of their research work might be done.

Dr. SHUTT: That is a difficult question to answer definitely and satisfactorily. Much would depend on the nature of the institute and its control, but I should say, if it afforded the facilities, that there are many agricultural problems that would very properly be better investigated by an institute entirely devoted to research. I have been speaking strictly with regard to the main features of the work of the Farm's system. In addition to what I have termed the educational work, the advisory work, the propaganda work of the Division of Chemistry, in addition to the investigation of agricultural problems, our laboratory has undertaken and spends a very considerable amount of time upon two phases of work which may be considered foreign to the Experimental Farm system. One is control work which has been undertaken for other branches of the Department of Agriculture, for instance, in connection with the Meat Inspection Division. In this connection a very large amount of control in regard to packing house and cannery products is done, occupying the attention of two technical assistants. Work has also been done during the last four or five years and is still being done in connection with the war. This may also be considered as control work. For instance all the flour that has gone overseas for military and civilian use has been examined and paid for on our analysis. To give you some idea of the extent of that work, I may say that we analysed last year more than four thousand samples of flour. The contracts were settled on the basis of our analysis. The authorities told me that between December and August last we controlled something like 1,300,000 tons of flour and that our work had saved to this country, or to our allies, something like $60,000 in rebates on excessive moisture which had been detected by our analysis. Altogether apart from these matters, we have undertaken a considerable amount of work for other departments of the Government service. There are Government departments which have no laboratories and these look to us for chemical assistance. As far as time and staff permitted we have rendered this assistance. Thus, chemical work has been undertaken for the Naval Department, the Post Office Department, the Interior Department and so on. For instance, we have just completed an investigation which has resulted in the devising of a new cancelling ink for the Post Office Department whereby they hope to effect a saving of several thousands of dollars a year, and

have a better ink than that which is used at present by the post office in cancelling stamps. I merely mention this to show you the wide and varied character of our work and by way of pointing out that we are not able to devote our whole time and attention to agricultural problems.

With this brief statement of our work I may ask if your question is, whether I favour the establishment of an institute for agricultural research or whether I think the Experimental Farm system should be so developed as to provide for the proper assistance and equipment for that kind of work.

Mr. THOMPSON: That was not exactly my point. My view is that ink work, for instance, should not be done by you at all. that is something that should be done by a central institute. You have researchers for agriculture problems. Agriculture is one of our great resources. What I wish to know is whether in your judgment it would be better to extend the system which you already have and of which you are the head in the Department of Agriculture, or establish a central research institute here, or somewhere else in which certain kinds of research work would be done that is at present done by you.

Dr. SHUTT: A central research institute could do a part of the work and do it well, but from what I have said as to the necessity of land and plants and animals in the solution of agricultural problems it must necessarily follow that if we had a separate agricultural research institute provision for these would have to be made. All institutes carrying on agricultural research are so provided. To carry on its work effectively and economically such an institute could be affiliated with the Experimental Farm system. For if it did not use the lands of the Experimental Farm system, such lands would have to be acquired in different parts of the Dominion, in order that the factors of soil and climate may be studied in connection with the investigations. I am speaking not only of chemical work but also that of biological character. Consequently any severance of the chemical investigational work from the Experimental Farm system would be detrimental to agricultural interest, unless provisions were made by the Research Institute for land and crops and animals. It seems to me that such would be an unnecessary duplication. It is a debateable subject, but from what I have already said as to the development of certain phases of our work, it is evident that the purely scientific work of agriculture must be proceeded with if we are going to make any material progress. It is only the facts as revealed by scientific investigation which will place us in a different position to-morrow from what we are in to-day—it is only by ascertaining these facts, these fundamental facts that we can make progress. We can demonstrate and set forth the knowledge that we have at present, and this is valuable, but if we are to make any permanent advance there must be scientific investigation. That brings me to another matter. If there is to be good work in scientific investigation it must be uncontrolled, in the sense of being free from petty regulations. There must be an opportunity for continuous and uninterrupted, patient and free work, and that work must be done in the right atmosphere. It is the same in science as it is in art. The investigator ought to be as free as possible from routine work, and from the rules and regulations found necessary in the prosecution of routine work. I think in this science is very much on the same lines as art, that is in the higher planes. The routine, which is inevitable in the larger number of governmental institutions and laboratories is irksome to the investigator. The scientific worker considers irritating and annoying the rules and regulations of a hard and fast discipline. They are not merely distasteful, but they spoil and prevent the best work. Indeed, in my opinion, they are absolutely inimical to the best work being done. You have asked me whether I would enlarge the present Farm system or whether I would like to see a separate institution. It occurs to me that any wise and successful development of say the Division of Chemistry, with respect to purely investigational work, would mean its being set free from purely departmental rules

and being relieved of a very large amount of work which falls to its share at the present time. I am not complaining. If I had any complaint to make, this would not be the place to make it. I am merely stating what is necessary for investigational work of the most profound character. I know it is one of those inevitable necessities of Government departments that there must be these things of which I have spoken. There must necessarily be routine and regulations and restrictions which would preclude the possibility of the highest class of work being done.

Having said so much, I would say this in answer to your question: It is possible to develop the Division of Chemistry, and to do more work and better work in connection with agricultural problems with which chemistry may be more or less related and of which there is a large number, but such is scarcely possible under purely governmental control and conditions. Chemistry is a fundamental science in connection with the larger number of our problems. It is possible but it would not be at all desirable to have a remodelling of the present system by merely adding to the staff and to the accommodation and equipment. That is my opinion. Research is not best carried on solely under Government regime. The controlling and directing body of a research institute should be made up largely of scientific men. I am sure matters will not be satisfactory if such is not the case. Government of course should have its share of control, but this should be chiefly as regards finances. The board of trustees should have among its members the best scientific men in the country.

Mr. NICKLE: I think that what we want to know is—we are all agreed as to the wisdom and necessity of scientific research—what we want is information from the point of view of agriculture as to what would be the best method of securing results from that Department; whether there should be a central institute; whether the system at present in vogue, should be continued, or whether you can suggest some other system in regard to the Experimental Farm and the Department of Agriculture.

Dr. SHUTT: That is not an easy question to answer satisfactorily off-hand. Some consideration as to plans and details would be desirable. It has been a matter in the minds of many of us for years but I confess that I am not prepared at the moment to lay down a hard and fast plan which would be workable with regard to that matter. Several schemes might be considered.

Mr. NICKLE: Do you consider the matter as a debateable one?

Dr. SHUTT: Yes, I do. In that connection, I feel that it would be highly desirable, if it could be satisfactorily arranged, that the control and direction of the purely investigational work could be placed in the hands of a board of trustees in which men from the universities, as well as the Government, would have a place. I think that would be highly desirable. Indeed, I think it is really necessary to secure the very best results; there should be men of science, intelligence and training to encourage and direct the work. That would, of course, mean a distinct breaking away from the system as it is at present. There is no doubt that a larger amount of money would be necessary for the support of such an institute or division and this would have to be found by the Government.

Mr. MCGIBBON: You would prefer having purely agricultural problems left with yourself in your own laboratories.

Dr. SHUTT: What I wished to make clear was that I would like to have the agricultural problems separated from the larger amount of the necessary routine and control work which occupies time and diverts the attention from regulations, which are more or less irritating and annoying. I also say that the establishment of a research institute in a building merely could not adequately undertake the solution of agricultural problems, unless lands and other necessary equipment were provided. Possibly if the National Research Institute under the control of a Board of Trustees, were affiliated with the Experimental Farm System, the Division of Chemistry, might be

transferred to the Institute with good effect. Or the Division of Chemistry might be made into a separate Branch or Bureau for purely investigational work with agricultural problems, but it would be necessary to have it affiliated with the Experimental Farm system in order to provide land, etc., the working out of many of its investigations. Under the latter arrangement however I do not see how it could be arranged to have the direction and control save under purely governmental conditions—which in my opinion is not conducive to the highest class of investigational work.//

Dr. C. E. Saunders, Dominion Cerealist: I was not here at the commencement of Dr. Shutt's remarks, and I am not quite clear whether you expect me to say something on my own initiative, or whether you will ask me questions.

The Chairman: I said that we were here, in the first place, to ascertain the nature in Canada of the development of scientific industrial research, and to determine the best method, if that is thought advisable, of furthering that end, and in the second place, I said, with some hesitation, that we felt we should inquire as to the advisability, if a central institute were founded, of bringing about co-ordination between the various scientific branches already established by the Government. Those are the two main points.

Dr. Saunders: It seems to me that an institute such as is being discussed could take up agricultural problems perfectly well, but of course entirely within its four walls. It would require land and buildings (not extensive ones) at various points where this work could be done. For some reasons, it would seem to me desirable that the purely scientific part of agricultural investigations should be separated from the present experimental farm system. Possibly the institute might use small areas on the experimental farms; but it would probably be better for the institute to entirely control such land as would be needed for research work, in agricultural science. The main difficulty, as it seems to me, with which we have to contend at present, and with which an institute might have to contend, lies in the control of the work by the Government. Speaking frankly but without any personal feeling, I should say that government control is based on the idea that immediate success is to be aimed at no matter what sacrifice of ultimate good may be necessary. The proper method of control, which I might by contrast call the university method (although some universities are managed like some governments) the proper method is to look not for immediate success, because immediate success often means permanent failure, but to look for light. Those two words *success* and *light* express the contrast between the two methods as well as I can put it. The Government looks for success for obvious reasons. Governments wish to please the people. They wish to be re-elected, and the ordinary voter wants results right now, just the very time when they cannot be had. At any cost therefore he must be convinced that success is being attained. Under the other method of control of scientific work one is encouraged to seek not immediate success, but light—a very much finer and more important aim. Our experimental farms to-day are spending most of their time instructing the farmers, making demonstrations—very important work too—and solving little problems of a semi-scientific character. But we are doing scarcely anything to advance the science of agriculture and are obliged to depend on scientific researches performed in other countries. I think it is extremely undesirable that Canada, now that we have come to a sense of national responsibility in some respects, should be permanently dependent on the rest of the world for all its basic agricultural science. But I see no hope whatever for the experimental farms, as they are now established and governed, ever becoming the scientific institutions they should be. There are too many things that the Department requires from day to day, and these petty details prevent proper work being done. Laws and regulations are steadily increasing in number and red tape has become a tragedy rather than a joke. It is impossible for a man who has not done scientific work to fully

realize the futility of trying to carry on difficult researches (for which freedom of action and an undisturbed mind are essential) when one is impeded and harrassed by all sorts of annoying regulations and demands. I am not criticizing the work the farms are doing. It is useful work, but it is not what I think they were intended to do, nor what they should do. We are working at the public end of matters and not at the scientific or basic ends. We are giving out information rather than acquiring it. We are erecting a fine looking structure on insufficient foundations which are already crumbling away.

The question arises how should an institution for scientific research be governed. If it is to be a section of an ordinary department of the Government service there would be no use trying to do the best type of scientific work in it. There is no hope for scientific research in its best form unless an institute be established which is not under direct, daily, departmental control. Scientists are different from ordinary labourers or other men doing any kind of so-called practical work, and they are different from ordinary clerks. They cannot do their best work when they are regulated. If a scientist is busy thinking he should be left alone and allowed to think as long as he wants to, and the idea of having to sign an attendance book at nine o'clock next morning must not be permitted to interfere with him sitting up all night if he needs to do so. He must be largely his own master. Regulations and limitations destroy the right spirit. A worker in science must have peace and he must have the proper atmosphere. If these essentials are not provided his work will seldom amount to much. I spent four years in researches in pure science at two of the best American universities and I have occupied my present position for over sixteen years. I therefore, know at first hand the difference between the atmosphere of a university and that of a department of the Government. If an institute for scientific research could be established under the control of an independent board of scientists, it might accomplish a great deal both in pure and in applied science. Such an institute could, I think, very well take over the study of the great basic problems of scientific agriculture, while the experimental farms might continue to be demonstration farms, teaching institutions and propaganda centres for good farming. But if the institute is to be organized and managed in the usual way, it will be just as unsatisfactory as are the experimental farms from a scientific point of view, and there would not be any object in transferring any of our work to it.

There is one other point I should like to emphasize in this connection: Those of us who are trying to do scientific work on the farm have found that under present arrangements, scientific papers are refused publication. The Printing Committee will not pass them. Now, with all due respect to that committee, I do not admit the right of any one but a trained scientist to pronounce upon the value of a piece of scientific work. As long as a committee, composed of men who are not versed in science and who are unsympathetic towards science, is allowed to decide what shall be published and what shall not be published, it is not worth doing any very fine work.

Mr. NICKLE: Do I understand the committee will not permit the results?

Dr. SAUNDERS: Not unless the committee consider them of "practical" value. The chairman of the committee told me plainly that he would not allow the publication of purely scientific papers. I went to him having in view the publication of some of my studies in heredity in cereals; but I found that there would be no use submitting them at all. I shall be obliged therefore to have them published somewhere else—not under government control.

Mr. NICKLE: Do I understand that in regard to the research work done on the Experimental Farm the Printing Committee reported against the publication of it?

Dr. SAUNDERS: I do not know how far the committee has gone in rejecting matter which has actually been submitted; but we have been warned that the committee will

only publish such articles as they consider of practical value—such as will increase the supply of bread and butter, I suppose.

Mr. McGIBBON: Was that ever brought to the attention of the Minister?

Dr. SAUNDERS: I could not say. But I know that other departments of the government service have encountered the same difficulty. I understand the Research Council has not had plain sailing. Manifestly it would be absurd to establish a Research Institute if it could only publish such results as pleased a printing committee which is frankly hostile to science as such.

Mr. THOMPSON: I understand from Dr. Saunders that he thinks that the routine work which the agricultural stations are doing can be continued there, but that there are certain matters in connection with research that could be better done in a central institute.

Dr. SAUNDERS: Yes, provided the institute were so organized as not to be subject to departmental routine.

Mr. THOMPSON: That goes without saying. I would like to get Dr. Saunders' opinion as to whether this research work could be better done in a research institute or whether it should be divided among the laboratories of the universities in Canada.

Dr. SAUNDERS: Perhaps it might be done in both ways. But I am quite sure of this, that the universities of Canada should have some research work to do, because we must look to them for the training of the men; and I think the Government ought to take cognizance of this fact in establishing a central institute, and should assist the universities to become training centres for scientific workers.

Mr. McGIBBON: That would not necessarily mean that they would have research work to do.

Dr. SAUNDERS: Yes. I think they would require to do such work at the universities. A good research specialist can (usually) only be produced by carrying on post-graduate researches for a couple of years at least at a university.

Mr. McGIBBON: Would it not require that a man should have graduated in fundamental science previous to taking up agricultural research?

Dr. SAUNDERS: Certainly he should have a broad scientific education.

Mr. McGIBBON: Would that not be an absolute necessity?

Dr. SAUNDERS: Yes, a broad training would be necessary before he specializes in agricultural or any other science, because, otherwise, he would have much too narrow an outlook.

Mr. McGIBBON: Would the university part of his training be the first part, rather than the latter part?

Dr. SAUNDERS: The university part is to train a man up to the point where he is fit independently to take up the great problems that will be submitted to him. I should say that the universities would require to have a regular department of agricultural science where post-graduate work could be carried on, before we could expect to get men from the universities fit to be leaders in a central institute. It would obviously be undesirable to import the whole staff for such an institute. I do not think that Canada should contemplate any such course.

Mr. NICKLE: You do not think that there is any marked cleavage between industrial research and pure science as we ordinarily use that word?

Dr. SAUNDERS: There is a distinction, certainly, but one runs into the other. Industrial research looks for light on a specific detail. The scientific worker as such, is looking for light too; but if he is advancing in one direction, and perceives more light in another, he turns and goes after the larger light. That is why he must not be worried by instructions to hand in a report on that first subject by the end of the

month, because he may have discovered a far more important subject on which he can submit a splendid report in the course of a few years. He must be allowed to decide for himself what is most important to be done.

Mr. NICKLE: In endeavouring to obtain the greater light, he may be led to something of much greater importance than the problem to which his attention had been first directed.

Dr. SAUNDERS: That is the idea.

Mr. NICKLE: Very often pure science may turn itself to industrial advantage.

Dr. SAUNDERS: It does. It is the foundation. Applied science is built on pure science. But the great, basic laws of science are rather like Maeterlinck's blue-bird of happiness, very difficult to find if you hunt directly for them. In pure science you do not always get what you start out to seek, but you may discover something far better. The whole of an aniline dye industry of Germany was based on an accidental discovery made by a chemist who was carrying on a research in another direction.

Mr. NICKLE: In order words, the pecuniary advantage of some knowledge that is obtained today may be thought to be negligible, and yet in the realm of the ultimate future it may prove to be of immense financial advantage.

Dr. SAUNDERS: Yes, sir.

The CHAIRMAN: You were speaking of fundamental problems which are so difficult to follow out and investigate when the investigator is constantly interrupted by routine matters. In your opinion, is it possible to have any government institution which could deal with fundamental problems?

Dr. SAUNDERS: I think so, although I think that the proper spirit could more readily be obtained under university control. But if a research institute were governed by an independent commission of scientists a good atmosphere for scientific research could be provided. But, as I said before, I would not consider such an institute as likely to be useful in pure science unless it were organized on an independent plan and were given very much more freedom than is generally allowed in government departments.

The CHAIRMAN: As things are at present constituted, and in view of the practical and political defects which must always prevail, do you think that a central institute, if founded here, would be of any use to the Department of Agriculture in solving its laboratory problems? Would there be some co-operation between the Department of Agriculture and such an institute?

Dr. SAUNDERS: There might be. So far as my work is concerned, nearly all my problems are filed problems, but I have a few problems which could be perfectly well dealt with in such a place. I do not know however that there would be any great advantage in removing the laboratories from where they are now situated. Practically all of the more scientific part of my work is done in the field, and could not of course be dealt with within the walls of a building.

Mr. MCGIBBON: I take it that you would rather have the laboratories under your own direction than in an institute in Ottawa.

Dr. SAUNDERS: Yes, for personal reasons; but I do not think it would make a very great deal of difference, so far as the work is concerned. Milling and baking laboratories like mine were established by the Department of Trade and Commerce for essentially the same kind of work. Consequently the two over-lap a good deal. Both could be combined in a new laboratory to do all the work, which might be more economical.

Mr. MCGIBBON: I am not looking at it from an economical standpoint, but from the standpoint of whether it would be better to have one directing mind, or a number of directing minds.

[Dr. Saunders.]

Dr. SAUNDERS: That would depend a good deal on the minds in question. Sometimes there are advantages in having more minds because more problems are taken up. Laboratory work is not a large matter in my division. My fundamental, scientific work is chiefly in the study of heredity in plants, which of course involves field work; but there is no reason whatever why a central institute could not control such field work if it were thought desirable. It could purchase or rent the small areas required. It is only when the work becomes of a more practical character that large areas are required for the propagation of the best new sorts of cereals.

Prof. EDWARD E. PRINCE: I propose to confine myself very largely to the fisheries as a great natural resource of this country, and a lucrative industry because I feel that the future development of our fisheries depends upon scientific knowledge more than anything else, and that the decay of the fisheries, which has already begun, is due very largely to ignorance. There is no greater source of decay in exploiting any great natural resource than ignorance. The fisheries have already shown signs of some decline, so that I am an advocate of scientific research and scientific knowledge in regard to this great natural resource. I do not know whether the members of the committee are familiar with my work, but without I hope being regarded as egostistic I shall devote a few words to my experience.

I was appointed in October, 1892, as scientific adviser upon fishery matters by Sir Hibbert Tupper, who was at the time the Minister of Marine. He felt the need of scientific advice. He had plenty of what was called practical untrained advice, officials who knew all the red tape of the department; but, as he told me himself, he felt that he needed some advice continually on fishery questions from some trained man, and as I had had great experience in Scotland, England and Ireland, having made quite a number of fishery surveys and having also been one of the pioneers in the study of fish life in the sea, he thought I was qualified for the position, and I was appointed.

During many years of my official life, I have felt what others have expressed to-day, that official rules and routine do not encourage a scientific man. He feels himself hampered at every point, and consequently carries on any scientific work which would be of benefit to the country, under great difficulties. As an illustration of what I mean by a scientific knowledge having a practical value in regard to the fisheries, I will refer to the circumstances which led me, when attending the university in Scotland, to take up fisheries research and become a fishery expert. The British Government had been asked repeatedly to pass laws in regard to steam trawling, and to prevent this method of fishing upon certain grounds in the sea because they were said to be spawning grounds. Commissions were held under great authorities like Professor Huxley and others, at which evidence was given by fishermen. Some fifty thousand Scottish fishermen testified that great quantities of spawn were destroyed by steam trawling, that the young fish were destroyed in immense quantities, and they urged that laws be passed to stop that method of fishing. The fishermen were asked where the spawn lay. They described the spawning grounds and told how they got up specimens of the spawn from the bottom. I was appointed by the Scottish Fisheries Board to work under a very distinguished authority, in fact the greatest authority on fisheries living, I think, Professor McIntosh. He asked me to find out where the fishes laid their eggs. I dredged and trawled for quite a long time from Government boats, and could get no spawn whatever on the banks which were claimed to be the greatest spawning grounds for haddock, herring, flat fish and plaice. I then used tow nets in the water and I found that the eggs of the fishes instead of being at the bottom, as fishermen had said, were floating near the top, and that the fishermen were all wrong in their opinion that the trawl destroyed the spawn, for the simple reason that the spawn was not at the bottom to be destroyed. The laws preventing trawling on alleged spawning grounds were therefore entirely erroneous, and I am glad to say that this fact awakened the public mind, and it

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awakened the fishermen too, because they burnt in effigy some of the men who made this discovery of floating spawn. The public were awakened, and they said: We must not rely on the evidence of practical men any longer; we must get expert information, and that led to the Scottish Fishery Board inaugurating a system of fishery researches which have been carried on ever since. Every enlightened country has done the same thing, has carried on fishery researches in their seas and lakes and rivers with great advantage to the fisheries; so that the late Lord Lyon Playfair, who knew a great deal about this work, announced in the House of Lords a few years ago that fishery laws based on unscientific information were worthless and harmful. He gave some examples, citing particularly the herring industry as being directed by laws based on unscientific information which had proved destructive to the herring fisheries on the west of Scotland.

I may say in parenthesis that the herring is the only fish of great economic value that lays its eggs on the bottom. I may also add that trawlers cannot trawl on herring spawning ground because it is very rough rocky ground as a rule; so that herring are protected in that way.

I have been the scientific advisor to a great extent in the naval service of the Department of Fisheries for many years, and have continually been giving scientific opinions on various matters. It would astonish perhaps the committee to know that I get letters from all parts of the world asking for information on fish and fisheries. Within the last few days I have received letters from New Zealand, Australia, and India asking my opinion as to fishery questions. Of course, I have gathered a great deal of information about our fisheries all over Canada, and have visited practically every part of Canada with the exception of the Yukon. I have also been chairman of about twelve government commissions appointed to investigate various fisheries, such as lobster, or shad, or salmon in British Columbia, the Government having felt that a scientific man at the head of these committees of investigation was desirable. I am also chairman of the Arctic Expedition Committee, of the Fish Refrigerating Committee of the Research Council; and for many years have been a member of the international commission dealing with international fishery questions under the Treaty of 1908. Fish hatching and hatcheries were for fourteen years (1895-1909) under my charge, though placed under other superintendence in recent years. What struck me very much as a departmental official was the uncertainty when technical problems arose as to who should deal with them. If it were a question of say the analysis of samples of water from lakes in which we were going to plant fish they might go to six or eight different authorities; frequently they were sent to Dr. Shutt, Central Experimental Farm. He has done a great deal of this work as a scientific analyst. It might go to the Inland Revenue Department's chemist, or to the Customs Department's chemist, or to half a dozen other departments which have chemists on their staffs who can undertake the analysis of water. I often felt that there should be some one authority to which these samples should go. There are at least ten different departments that are at present dealing with fishery matters. There is the Naval Department, the Interior Department, which deals with fisheries in some reports; the Inland Revenue Department, the Customs Department, the Department of Trade and Commerce, the Mines Department, the Census Bureau, which recently published an extended report on fisheries, the Agriculture Department, and the Natural Resources and Conservation Commission. Most of these reports published by commissions and departments, other than the Fisheries Department, are compilations instead of being original work by men who are experts on fisheries.

This waste of energy and duplication, and re-duplication, seems to me one of the greatest weaknesses of our present system and some centralization is absolutely necessary where scientific questions dealing with fisheries, as with other matters, can be dealt with economically by qualified experts. I know I am on controversial ground but

official heads like to have big departments and the more officials they have the more credit they think attaches to themselves. So that each department wants its own lawyer, architect, biologist and medical officer, and all duplication goes on in order to enlarge the staff and make the department important. The idea is duplication and waste of money. What is the remedy under this condition of things? I, myself, suggested in the Fisheries Report, 1893, page 188, the creation of a biological station. This has grown into a system which is under the Biological Board of Canada. The Biological Board of Canada was started in 1898 and worked for under the Naval Department, which was then the Fisheries Department, but it found itself so continually hampered and trammelled by red tape and all kinds of petty official interference that there was some danger that the best scientific men would resign from the Board. For the sake of efficiency it was represented very strongly to Sir Douglas Hazen, when he was Minister of Fisheries, that the Biological Board must be made more independent of the Department but still under the Minister's control. This was done. A special Act was passed by Parliament. The Biological Board Act, 2 George V, chap. 6, and the Biological Board was given that freedom which was essential to successful scientific work, and for some years now the Board has gone on successfully doing its work in a most satisfactory way as the Deputy Minister has cordially testified, free from red tape official interference. The results have been that quite a number of important reports have been published. These reports are mainly the work of scientific men who have worked without fee or reward. The Biological Board consists of nine men, including myself. They are representatives sent by the great universities and all are eminent Biologists, McGill, Toronto, Laval and Queens and other universities are represented on this Board. By the Act creating this Board these men are precluded from taking any honorarium or fee. They do their work gratis. Their expenses are paid and their board. I am the only paid official on the Board. Dr. Macallum is the Secretary-Treasurer. This splendid work has been done largely by the honorary system. Some junior biologists, who are distinguished graduates, appointed by the Board to do definite work, receive somewhat inadequate pay, and recently the Board appointed two permanent officers in charge of the stations, one of whom is on the Atlantic coast, and the other on the Pacific. About 150 reports have been published, by the Biological Board, of work done at these stations. I would like to indicate in a few words what the reports cover, so that the Committee may see that this technical scientific work is of practical importance to the fisheries. Broadly speaking, the reports cover about 10 separate fields. They are, first of all, problems of a strictly practical nature, like the sawdust question as affecting fish life, also experiments with respect to the use of dynamite and other explosives. Dynamite and other explosives have been used by the fishermen, and the effect of that was investigated and it was shown how harmful it was. There have been bait experiments and tests with different kinds of bait, to inform the fishermen how they might use neglected bait resources and make better catches of fish. Very important investigations were carried on upon our valuable seaweed resources. The great B. C. kelp beds were investigated by Professor A. T. Cameron, of Winnipeg, who showed what great commercial products might be secured from this source. The question of freezing and curing fish has been investigated and these curing experiments have had good results, because under a distinguished lady, a biochemist, Dr. Olive Patterson, the fish were cured under the best scientific conditions. Specimens were sent round to members of Parliament and to various authorities to ask them what they thought of these cured fish which were prepared by the Biological Board, and they were unanimously declared to be the best finnan-haddie that ever appeared on the table of these people who got them. That was an important practical result. It was shown how the best finan-haddie could be produced. The finnan-haddie generally prepared in Canada have not the high repute in the market that other finnan-haddie have. They are supposed to be an

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inferior production compared with the Scotch and English finnan-haddies . Then there was the study of the food of the finny tribes, because wherever the feeding grounds are found the fish will gather, and it is important to know therefore where the food occurs. There are a number of reports by Professor R. Ramsay Wright and iProfessor Playfair McMurrich on this question of floating fish food, etc. The Board planned studies of the diseases and parasites of fish, and on the spawning habits and life history of fish. These researches are in many cases still going on. The study of fishing operations, fishing gear and the use of various new baits is an important field and must be of benefit in the future to the fishermen. We have had special investigations on the oyster and the clam beds. It was found that much needed information of a technical character was entirely lacking in regard to oysters, clams, scallops and other shell fish and valuable reports have been issued dealing with them. Then a very important problem was the great lobster industry. We have had a special investigation in regard to the decline of the lobster, and methods of restoring the lobster to plentitude and a number of reports have been published. Then we have had chemical, hydrographical and physical investigations of the waters which form the habitat of fish, and these bear vitally on the prosperity of the fisheries. These physical researches are of importance to the fisheries as a commercial enterprise. We also have a series of reports of a faunistic and botanical nature, a series numbering no less than twenty. These faunistic researches upon all kinds of life in the sea and in inland waters have a direct bearing on the abundance of fish. Then the Biological Board started researches on the utilization of fish waste and production of fish manures. This subject is one in regard to which several publications have been issued, and we have had great assistance from Dr. Shutt, of the Experimental Farm, in the analysis of fish fertiliser products, especially dogfish and other waste fish. This rough survey indicates what the Biological Board has attempted to accomplish and the large field the fisheries afford for researches at our biological stations. The question naturally arises, what is the best method of ensuring the best results from such technical researches. I myself have had experience of three different methods, namely, departmental researches under official departmental control; researches carried on in universities under academic conditions, and researches carried on in special research laboratories. From my long experience I unhesitatingly say that the research laboratory is the one in which the best work can be done. The enthusiastic trained worker can investigate and know that he is left free to do his work in the best way. I was a university instructor myself in Scotland, and I know that even there, however enthusiastic a man might be about research, the main object of the university staff is the training of students for professions. Everything is concentrated on that, on training men for various professions. It has been said that Germany is an illustration of the conversion of universities into research institutes. So far as they became research institutes they failed as universities. I will illustrate this by an example. A man who wanted to study my object, biology, might go to Jena in order to be under Professor Haeckel. I have known them do this; they have gone to Jena to study under Haeckel. But during the several years which they spent at Jena they never saw Haeckel, because instead of teaching he was busy with research. A friend of mine went to Heidleburg to study under Carl Gegenbaur, the great anatomist, and he told me that he never saw Gegenbaur the whole time he was there, he was so busy with research. An exceptional man may be able to do both research and academic duties, but the professor, who is doing his duty as a teacher, has his spare time only for research. Therefore, I favour a central research institution devoted solely to original investigation. The preparatory and thorough training of men for research is, of course, the great duty of a university. The fact is that in Canada we have too little of that special advanced training in the universities. The Biological Board has found year after year, that there were not enough men training to take up problems

[Porfessor Prince.]

which might be urgently waiting solution. Students are anxious to qualify for medicine, law, the church, etc., and there is a lack of men qualified to take up original scientific research.

Now, if the universities can devote themselves to the training of men for technical research, they will be helping a great deal in furthering the advance of scientific and practical work in the country. Professor Clark, of Queens, recently appeared before the committee and I believe admitted that he intended to devote himself to research at Queen's University by relinquishing his university duties proper. He would give up his teaching largely, and devote himself to research. Of course, the two things are, to some extent distinct. University training should lead to research. The student who begins research too soon makes a mistake. No man can begin research until he has had a thorough training in the general principles of science, chemistry, physics, and I would say languages, too, are necessary because in order to read scientific literature he must have a knowledge of several languages. Therefore, a university training is essential as a preliminary to advanced research later on.

Mr. WHIDDEN: Is it possible for a professor who is not doing a regular amount of research work to produce research students, to give them the spirit and the attitude. If they are diverted into merely routine instruction or have to devote themselves to the duties imposed upon them by the university authorities, how are they going to give the student of the third or fourth year spirit?

Dr. PRINCE: Any teacher in a university who is not an enthusiast has no place there. I remember that I myself was a pupil of Sir Michael Foster, the great physiologist, and he gave lectures in the University of Cambridge, but he inspired every student to go on with research. No man passed through Sir Michael's classes without feeling that he would like to take up some original physiological problem. That was the result of his ordinary university work preparing for the usual degree. I myself was inspired with enthusiasm under such great biological teachers as Professor Adam Sedgwick, of Cambridge, and Professor McIntosh, of St. Andrews. On the other hand, I have been under professors who killed enthusiasm. Perhaps these are men of the type you were referring to. A teacher in a university can inspire men to take up research by the instruction they give in the usual university course. I would not preclude a university from research, I would encourage it. In Scotland the regular university work does not kill the desire of the student to carry on research.

Mr. THOMPSON: Which system has produced the great scientists in England, such as Darwin, Huxley, or Tyndall, or Clark Maxwell?

Dr. PRINCE: I am very glad that Dr. Thompson has raised that point. We have been looking very critically at Germany lately. One of the most remarkable points about German science is that it is now recognized how very few men of the highest rank it has produced. The leaders in science, the great men in biological, physical and other sciences, are either British or French. Charles Darwin, Sir J. J. Thompson, Lord Rayleigh, Sir J. Y. Simpson, Lord Lister, Lord Kelvin, and a host of others who could be named as occupying the first rank. German scientists have looked up to British leaders. The German system produced largely not original workers but plodders at problems which other better trained, better qualified scientists gave them to solve. Darwin gave Germany a multitude of problems and she worked them out laboriously. If you want to produce original men the German system is not the system to adopt; it is a system by which profound problems thought out by great men are taken up and further developed. Imagine Sir Isaac Newton being told by a department or by a university to discover the law of gravitation. Sir Isaac Newton, founder of the modern science of physics was produced by a university system which is the system of thorough training and culture in the largest sense. I am very glad that that point was raised, because the more one looks into the question of original research, the more

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one finds that the German system did not produce the great pioneers and leaders in science, but mainly laborious and patient followers. Take radium studies, Professor Rutherford, late of McGill University, is one of the leading men in that most recent field of science. In France the same condition prevails. It produces original scientific leaders.

The CHAIRMAN: What is your view with regard to the aid which a central institute for research would give you in your special problems.

Dr. PRINCE: I rather think that it would be an advantage for the biological stations to be affiliated to some central authority. These biological stations deal with work in the field in which I have all my life been interested, and in some way they should be affiliated or connected with the central institute, so that it would be part of its system. As Dr. Shutt said in regard to agricultural researches, they must be carried on in the field and a large amount of fishery research likewise must be carried on in the sea and inland waters. It cannot be done wholly in a central institute, but the central institute, directing scientific body, would be able to give the direction and provide the apparatus for such researches and it would be of very great value to a department like ours to have the assistance of such centralized organization of eminent scientists to solve the problems.

Mr. THOMPSON: There is no doubt in your mind, I take it, that we should have a central research institute?

Dr. PRINCE: Yes, I think that would certainly produce the most economic results, and would avoid the duplication and waste in scientific investigation and in publication of technical reports which at present goes on.

The CHAIRMAN: Would you lay some stress on the need of having the same independence as your Board has?

Dr. PRINCE: I may reply to that by a personal allusion. I began and worked for many years as an enthusiastic fishery expert, and official Departmental association has knocked all the enthusiasm out of me. I am an enthusiastic scientist without enthusiasm.

Dr. MACALLUM: The present biological stations are open only for a certain time of the year. The climate determines that. These stations cannot be manned as they ought to be for certain problems, such as for instance the chemistry and bacteriology of the fish curing. Could not that work be carried on best by an establishment that would be open all the year round, by some central establishment Professor Prince?

Dr. PRINCE: Yes, the material could be secured in the sea and shipped and most satisfactorily dealt with. The material could be sent to a central point and worked up there as is the case in most scientific laboratories.

Dr. MACALLUM: Is not the bio-chemistry of fish products a subject that calls for special qualifications in the way of research training?

Dr. PRINCE: Bio-chemistry is such a new science that it is rather difficult for me to reply to that. It is becoming more and more important. It touches so many diverse fields. It is being realized that some of the most practical questions in regard to food are bio-chemical questions, and the bio-chemists require to be specially and thoroughly trained. We have a very few bio-chemists in this country, and there is a great and expanding field open. The universities would require to train bio-chemists. Students might be encouraged to take up bio-chemistry if they were assured that there was some permanent work for them in connection with the central research institute. At present, the bio-chemist may feel uncertain as to what may become of him after he has passed through his long and difficult training, and that is an important feature about a central institute, it offers careers to such men. A large staff of workers would be necessary and the best men could look forward to some permanent career. It would also insure

the publication of their results which, as Dr. Charles Saunders pointed out, is very important. The Biological Board has published a number of volumes from 1901 to 1918, and now we are warned that no more will be printed. A central institute would issue bulletins which would be of international as well as national importance.

The Committee adjourned.

FRIDAY, June 13, 1919.

The Committee met at 10.30 a.m., Mr. Thompson, Acting Chairman, presiding.

The ACTING CHAIRMAN: We have with us this morning Dr. Stratton, of the Bureau of Standards, Washington, who has very kindly come to give us his experience.

Dr. S. W. STRATTON, Director, Bureau of Standards, Washington, D.C.

The ACTING CHAIRMAN: We have no particular method of presenting the evidence before this Committee. Each witness proceeds to make his statement in his own way.

Mr. SHEARD: If the Doctor would kindly give us briefly an outline of the Bureau of Standards' work, it might be of assistance.

Dr. STRATTON: I have no special topics this morning, nor any particular way of presenting the matter. The subject is one in which I am greatly interested, and if anything I can say or do would enlighten the Committee on this subject of establishing a similar institution in this country, I am sure it will give me very great pleasure to assist you. I think perhaps you had better proceed in the way you are accustomed to, and I imagine your methods are not greatly different from the methods of our own committees. Do not hesitate at any time to interrupt or ask questions. It is only by questions that very often the important points are brought out.

First, the Bureau of Standards was established in 1901. At that time our Government had a small Weights and Measures Department which grew out of the necessity for standards of length in our coast survey service and standards of weights and measure in the Customs service; it consisted of four or five rooms, and perhaps half a dozen employees, it performed little or no functions for the public and its activities were confined to length, weight and capacity standard. At that time we were securing our electrical and many other standards from the German institutions. No provision was made for the standards of scientific work such as temperature, electricity, magnetism, etc. The law establishing the Bureau of Standards was enacted in 1901. It took two years to select the site, make the plans and erect the first building. The original appropriation was $250,000 for the building, which was divided into two buildings, requiring an additional $75,000, a staff of 14 or 15 people, and perhaps $100,000 for equipment. That would mean at the present time about double that amount. The bureau was located two or three miles from Washington, in a neighbourhood which we felt would be reasonably free from commercial or popular development. That has been a good thing in many ways, but it has had its drawbacks. We have never been interfered with as far as traffic or the development of a poor class of buildings is concerned, but the land about the bureau is largely held by speculators and it has been very difficult to get land for our extensions, and very difficult to secure houses in the neighbourhood of the character that our people wish. On the other hand, the traffic to this institution is in the reverse direction. Those who live in the city go out to the bureau in the morning, and they come into the city in the evening, so that the

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transportation problem is fairly well handled, and that is a question to which you must give careful consideration in establishing your own institution. I refer to the transportation problem and the comfort of the employees. It will add very greatly to the efficiency of the institution if it is established in a place which is accessible and around which the employees can live comfortably. The bureau site now consists of 30 acres. The recent acquisitions have been at a cost of $8,000 per acre, making approximately $200,000 for the site. The first building provided for was divided into two, and I think you will probably do the same thing. One building is a laboratory and the other containing the power plant and heavier mechanical facilities that always go with such an institution. That should be central. A building should be provided for this power and heating equipment about which all of the others can be grouped, the other buildings, as they have been added from time to time, are connected with this central building by tunnels. Steam pipes can be carried from one building to another. In investigational work one never knows what facilities are going to be required, and in the kind of problems taken up by the Government in an institution of this kind you are going to need exceptional facilities, you can install from our power house, as it is called, or mechanical shop, to any other room in any other building, steam pipes, water-pipes or electrical wires, without piercing the walls and without any great labour. That is a matter which your architect will look out for and about which we can probably be of some assistance. The type of building selected in the first place is reinforced concrete for solidity, faced with a very pleasant type of local brick and trimmed in limestone. In this country you might substitute your ordinary building material, but the particular feature of our laboratories is that the floor plans are much the same. Partitions are carried up from the bottom to the top resulting in a very strong cellular construction. You never know where you are going to put a heavy piece of machinery, weighing tons, or whether the apparatus is going to be a delicate mechanism. That has been a great surprise to us, and the most important thing that must be looked after in your construction. Our late building, the two that have been built recently, are what would be termed mill-construction, reinforced concrete for the floors, columns and walls and built very strongly; before the outside is put on you would say it was a factory building; the outside is put on with the same brick we have used in the construction of the former laboratories. The trimming is Indiana limestone, and makes a very presentable building. It would not be a good type in this country perhaps, on account of the severity of the winter, but it gives splendid light. Large broad windows give good light in the laboratories. Our laboratories are standardized in such a way that a room which is used for a certain thing to-day can be used to-morrow for another; we have followed that throughout, so that the question of growth is provided for. That is approximately 200 feet long, 60 feet wide and 4 stories high, and basement; there are six of these. The first one was taken as a general laboratory, the power house and shop was built at the same time; it is practically the same. It was the first of the large buildings. The others have been added from time to time. It is a very simple thing to move because we have standardized the laboratory rooms to a large extent. The next one built was the electrical laboratory so that from the first building the electrical section went to its permanent home, the next one built was the chemical laboratory. Every branch of work and almost every problem taken up involves chemistry of the most difficult kind and so we have met all these needs in the chemical laboratory. The fourth one taken up was the laboratory of metallurgy and a number of other things. During the war funds were provided with which to build a large laboratory for military purposes. Instead of building a temporary wooden structure we built the simple type of laboratory referred to, one of which was built last year. That laboratory is approximately equal in size to three and nearly four of the others. We have in all three small buildings that represents an expenditure of $75,000 each, six that cost approximately $250,000 each and one at $1,250,000, making approximately

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$3,000,000 as the accumulation of about 18 years. They have been built from year to year as the necessity arose and there has been no great burden upon the Government. The original plan was such that when a new building was completed some one moved out permanently and others got more room. The staff of the bureau at the present time is aproximately one thousand people. During the war it numbered something like 1,500 and we had 300 or 400 soldiers. We found that our drafts included the young scientific men, and like the other countries, our military authorities were on the point of assigning them to other duties, but fortunately they saw the need for them in the work of military development of a scientific character, and we were allowed to select experts from the draft. About 70 per cent of this normal staff of a thousand are scientific and technical and about 30 per cent clerks, workmen, labourers, watchmen, etc. Now the basis of the Bureau organization of science. The thing that has impressed me more than anything else is that you can reduce most all of these questions asked by the industries and by the public to the ordinary fields of physics and chemistry. So our organization is based upon the fields of physics, and chemistry and a few technical divisions, but even in the case of these technical divisions as a rule the work is based upon that of the scientific divisions. Now the questions of measurement are fundamental in commerce, as you know, and in industrial processes, so that the first thing done in the new bureau was the enlargement of the old weights and measures office into what we call the Weight and Measures Division of the Bureau of Standards.

The ACTING CHAIRMAN: Pardon me, is that the way the Mellon Institute originated.

Dr. STRATTON: Oh, no, the old office was under the Coast and Geodetic Survey. In 1901 the Bureau of Standards was established and it is rather important to keep that in mind because it absorbed the weights and measures work.

The bureau's work as originally planned and carried out in our first years consisted in addition to weights and measures, electricity and magnetism, heat, light, and other standards of measurement. We had almost nothing in our country in the way of provisions for standards of electrical measurements. We were going to German institutions for our electrical standards almost without exception. I think it was that one thing that influenced our Congress more than any other in providing for the establishment of the bureau; they had two hearings in regard to the bill and the fact that we were depending upon foreign countries for the standardization in connection with the standards of measurement was the thing that impressed the committee.

The relation of such an institution to the electrical industries of your country will well warrant the expenditure that you propose.

Our own institution receives many requests from this country along that line, we standardize electrical instruments for your individual units of industry and sometimes for your officials and I may say here that in case you establish this institution a great deal of good can come from the interchange of ideas. You will have an enormous advantage over us in that respect. At the start we had the experience of the work in Germany and of the National Physical Laboratory in Great Britain and they were of great assistance to us in establishing the bureau. Now you have the accumulated experience of all three institutions and can establish such an institution more economically and with a better organization. I see no reason why your institution should not work in the closest harmony with ours and I think it will. The relation between the National Laboratories is very close. No question pertaining to a standard of measurement is taken up and settled by our bureau without co-operating or at least corresponding with the National Bureaus of other countries. The closest relation had sprung up before the war and that will be continued and emphasized by the International Bureau of Weights and Measures in Paris, you can see that this is very essential if we are to have uniform standards throughout the world.

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When we took up the question of candle power we had one unit of measurement for gas and another for electricity; Great Britain was using one standard, Germany another, the candle power was different in each of those countries. Now it was not desirable to continue that condition; we cannot do that because standards are too closely related to the commerce of the world and I can give you many illustrations of that sort. One of the principal fields of standards is that of heat and thermometry. You can hardly realize what that means to the industries using high temperatures or to the manufactures in almost any field. Only a few years ago no uniform methods were available, very many industries depend upon temperature measurements for the success of many operations. There is hardly a branch of industry which must not have proper standards of temperature, and, what is equally important, proper methods of measurement. That is another thing to keep in mind. It is of no use to have a standard—you may develop all sorts of standards and measures and file them away, but the important thing is to make these accessible to the public. It involves not only the most difficult kinds of researches in developing these standards and methods of measurement, but the most difficult sort of work in making them available to the public, and in teaching the public how to use them. I know of no better illustration than heat measurement. Most of us are familiar with the thermometer. A few years ago we got our standards of the ordinary thermometer from abroad. Modern scientific work has made it necessary to measure low temperatures. We must measure the temperature of liquid air and liquid hydrogen. We are called upon to do that quite often. The separation of many gases depends upon that process. During the war, the production of the helium gas for the Allies depended upon that process. As you go up the scale, there are many temperatures to be measured in the industrial processes, from the boiling point of water up to the melting point of the ordinary metals. These temperatures are exceedingly important, but they involve an entirely different class of apparatus. Then there are the high temperatures used in all sorts of furnace work. That brings in another kind of instrument, if you provide the standards in the thermometry, and the methods of using these standards; if you provide the facilities for testing these things, and comparing that apparatus—and the standard is often embodied in the apparatus—with the standards which your institution sets up you will need the very best men in that branch of physics. It involves the most difficult sort of physics. We are familiar with the melting point of ice, and the boiling point of water. They are taken as fixed points, but to-day the melting point of metals and their boiling points of liquids are used in exactly the same way in the testing of the heat measuring instruments. Your institution will have to maintain and preserve all these things in such a way that they may be made quickly available to the public.

Another division is that of optics. But before we leave heat measurements, I think you can see that the question of measuring heat at industrial plants is a very important matter. These questions pertaining to the measurement of heat and the development of heat measuring instruments are just the same and handled by one group of experts.

The fourth division of the bureau's work is that of optics. You would be surprised at the number of optical instruments that are being applied in all sorts of industries, and especially in scientific investigation. A few days ago I was waited upon by three or four gentlemen representing an industry, and it was a question as to whether the colour of a certain material was permanent. While he waited, the sample was sent down to the laboratory and tested. I could give you many instances of the application of the principles of physics that possibly you have not heard of before. That is one of the great values of an institution such as this. Instead of having to wait ten or twenty years before a scientific discovery is made available to the industries, the institution becomes a clearing house for such information. It is the business of these people to know what is available. The ordinary manufacturer

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or members of the public can go there and see what is available in scientific data or methods, and it is marvellous how it works out in that way.

The fifth division is chemistry. As stated before, nearly every problem that we take up in regard to materials or in regard to the development of standards involves the purity of materials, and so one complete division is devoted to chemistry with a chemical staff. These are the scientific divisions.

Then follow the technical divisions which represent groups of applied science as it were, working with the industries on the one side, and with our own scientific sections on the other. The first of these is that of the engineering instruments and investigations. Throughout the industrial world there are a great many instruments, such as gauges, and meters of all kinds, water meters, and steam engine indicators. A great many of these do not come within the scope of the scientific divisions. This particular division handles that sort of thing and undertakes investigations which would be classed as mechanical engineering, but the work of this division is based upon physics and chemistry and it co-operates with those divisions.

The seventh division, or the second of the technical divisions is that of structural materials. That has to do with the leading structural materials. It is divided into several groups. The first has to do with metals, both ferrous and non-ferrous. The second is cement, concrete, stone and lime. The third is the clay products, and the fourth, miscellaneous materials such as textiles, rubber, lubricating oils and so on. You would be astonished to know how little is really known in regard to the actual properties of these materials. There is not a single one of these subjects under this structural or miscellaneous material work that would not warrant the expenditure of every dollar that our bureau expends every year.

For example, the clay products; when the war broke out we were importing all of our crucible clay for certain purposes, what we call graphite crucibles are used for the higher temperatures in many industrial processes. I think we were making $25,000,000 of them a year. The industries are very apt to follow along the lines of tradition. In our porcelain and china industries we use the English kaolin, a systematic study of our refractory clays—fire clays as they are called—has shown that by a suitable combination we can produce a better material than the German clay. We study clays from the standpoint of fire resistance, their load carrying capacity under high temperatures, their melting point, etc. Some will carry a very high load, but do not have a high melting point. Others are very refractory, but will not carry a load, so that a retort or furnace built of it will go to pieces. Now, by a suitable combination of these clays, we can produce a better clay than a single one. But think of the conditions that existed at the outbreak of the war, the making of our crucibles in which the metals for munitions were melted from German clay and Ceylon graphite and we had many such instances. Then again the questions of the clay products are very closely related to many other industries, such as glass-making, the question of glass-pots alone would warrant great expenditure on this material. In these days of new processes, the lining of a furnace must be adjusted to suit the thing that is being melted in it. I know of one case where a furnace lined with the wrong sort of refractory caused a loss of over $400,000. Gas retorts and crucibles, especially gas retorts and equipment of that kind, have to meet a much higher demand than before. It is almost impossible to get refractories that will meet with the requirements of modern development. That one thing, the researches in connection with the clay products, is an exceedingly important one, and in itself would warrant the establishment of such an institution as you propose. I cannot overstate the value.

Under miscellaneous materials we class paints and oils, paper, textiles, rubber, leather, lubricating oils and a few other things; the day has come when it is just as necessary to have standards of these materials as it is to have standards of measurements. We call them standards of quality. To-day paper is bought and sold by a

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specification and test, it is the same with textiles and other material. The day is not far distant when you perhaps will require the branding of all materials, and that it will be a misdemeanour to sell textile or paper or anything else for other than it is. It is coming just as we insist upon pure food, but, that is impossible, and cannot be done, until you have proper standards of these materials and methods of measuring. I think we would have had such a law some time ago in regard to certain materials if we could have made it possible to administer the law. Such a law cannot be administered until you have your standards and methods of measurement. I know of no subject that needs investigation more than rubber. I mean from the standards of both the manufacturer and the public, and in these matters we must always keep in mind the interests of the public. It is not all one-sided and is not all for the industry, but in the long run the interests of the public and the manufacturer are just the same. The user wants to get the best material that is suitable for his purpose. It ought to be the manufacturer's object to make the material that is wanted in the most economical and efficient manner. The two things are not at all inconsistent, in fact they go hand in hand, and if we undertake to establish a standard of the materials, the process is always the same. We call together the typical users. Such cases often arise, we sometime take from the Government service our typical user to begin with. It may be rubber, leather, textiles, or what not. We discuss with these users their needs. We try to locate, if we can, good as well as bad articles or material. Take the question of lubricating oil; we ask the Government engineers for samples of oil that have been found satisfactory, and what is equally important, for samples of oil that has failed, or any other material, whichever one we happen to be discussing. Then as a laboratory, we try to find out why the one is good and the other is bad, and build up what is ordinarily known as specification. It is going to be called a standard of quality. The term "specification" will disappear, and the standard of quality will take its place in a great many cases. Then we call in the manufacturer. He looks at this and he criticises it. He says, "I can't make this," or "I can make this." Usually he makes valuable suggestions to the laboratory, and aids in building up the standard. Then the material as specified must be made, and so you have a hand in hand relation between the manufacturer on one side, the user on the other, and the investigations of the laboratory. You would be surprised to see how that does away with the differences between the user and the manufacturer. We have the establishment of a standard which the user says is a thing he wants. The manufacturer says, "It is a thing I can make," and the laboratory has put it in scientific terms, so that it can be measured just as you measure yards and pounds. That is just as necessary in good business as good weights and measures. But the great work of such an institution is to make such scientific investigation as may lead to an improvement of the standard and hence the quality of the material, the object sought by both the user and the manufacturer.

I think you would be interested in some of the other things that are involved. I will refer to our appropriations for the present year, the one which is just about to close. Our fiscal year ends June 30, it includes considerable military work. We have two forms of appropriation. Most of the regular government bureaus are provided for by specific or statutory appropriations, so far as personnel is concerned, that is each salary is fixed by law. It is a very good thing for clerical service and service of that kind which has been standardized. It has turned out to be not a very good thing for scientific work, because there is too little flexibility. The Legislative Bill carrying these provisions designates each salary, so many physicists at such a salary each and so many associate physicists, and so on. Then in addition to this regular budget we are given from time to time certain sums for handling specific problems. Now for the past year our regular appropriation for statutory positions, equipment and lump sums, from all sources, so far as legislative action is concerned, $1,185,000; for the

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large building from the National Security and Defence Fund, the amount was $1,250,000. Congress appropriated during the year for special military work at the Bureau, such as military researches and standardization of munition gauges $400,000. Then there were transferred to us certain sums from the military department, the aviation service, and other services wishing problems solved, would come to the Bureau, and finding our own funds not sufficient, would transfer funds to carry it on, and I think we had something like half to three-quarters of a million, so that during the year our total expenditures were something like three millions.

For the coming year, the regular appropriations already made amount to $1,400,000, as compared with $1,185,000 for last year, showing that notwithstanding the wave of economy that is spreading over the country, and the discontinuance of military funds, our regular appropriations have increased. Supplemental estimates have been submitted for half a million dollars. Quite a number of urgent things have come up which have made it necessary to submit supplemental estimates to the amount of half a million dollars. The transfers during the year will probably amount approximately to $100,000, making in all a total of $2,000,000 appropriated or requested for the coming year. Leaving out the cost of the large building, the appropriation for which is very close to what we had last year, the appropriations show that there is a growing appreciation not only on the part of the public but on the part of the members of Congress, of the value of the work of the Bureau. This sum of $1,400,000 for the coming year is divided as follows: for statutory salaries, $486,000; for equipment $100,000; for general expenses $60,000; for repairs and alterations of buildings $8,000; for care of grounds $6,500. That is the regular budget, salaries, equipment, and for non-expendable things. These items will be of interest to those of you who I hope will be called upon to submit the estimates, a great deal depends on the way the estimates are prepared. We have classified our expenditure into equipment consisting of inventoried apparatus, and general expenses consisting of expendable things such as coal, gas, railway travelling, and so on. Then for structural materials there is $125,000. As I have explained this structural material work has to do with the development of standards of materials. That fund is not at all sufficient. By means of it we are enabled to test a tremendous amount of government purchases of material. I do not know whether that has been considered in connection with the proposed institution here, but it will certainly have to care for the standardization of materials. That one item alone has meant a great saving to the Government by enabling it to make its purchases properly. That fund also provides for investigations and tests of building material, under it we test all the cement used in Government buildings, and much of the steel and other materials. The amount of cement tested by the Bureau last year, if done by ordinary laboratories, would have cost $200,000. That was unusual, and the work was carried by the transfer of military funds. Then for testing machines there is $30,000. We have a very large testing machine in which we test building columns and other beam material. The first programme carried out was one of a series of steel columns. This programme was planned by the civil engineers. They explained what sort of columns they wanted to use, and what were the commercial shapes. We had these columns made and tested them on the machine. Out of this work will grow a lot of information that enters into the work of architects and engineers. The architect and engineer looks at a table to see whether a certain column will carry a certain weight; and some one has to produce these tables of the strength of columns.

Finally, there are the fire resisting properties of materials. Our building codes in some parts of the United States are in frightful shape. Most of them have grown up in various States based upon traditions. All sorts of peculiar things have crept into them, and there is an evident desire throughout the country to have more consistent building codes and especially buildings with fire-resisting properties. The loss by fire in our country is enormous every year, and so we have $35,000 set aside for

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investigating the fire resisting properties of materials. We take concrete columns and put them in a furnace, and find out how these columns stand up in a fire. We take steel columns which have been fire-proofed, covered by some fire-resisting material, and subject them to a test. That is a problem which involves physics, and physics of the most difficult kind. Information is coming out of that fund of unmistakable value.

Then we have an appropriation for public utility work. That is another important branch of work to which I would direct your attention. The day is coming when public utilities are going to be regulated to a certain extent. The public at present are more or less suspicious of public utilities, and unfortunately the men who have to do with the making of regulations and laws affecting public utilities are rarely familiar with the scientific things concerned in them. In our country at least, they have had to go for this information to the people who were trained up in the particular public utilities, and naturally they will always give their own side of it. There is the greatest need for an institution where State officials or public service officials can go and have ready access to information that is scientific and accurate. In the States we have much litigation with regard to the damage to water pipes by electrolopsis and with regard to the right method of installation of electric wires, water pipes, etc., and as to what is fair and just to the company as well as to the public. You will find that such an institution will supply a long felt want in acting as a mediator between the public and the public utility companies. We call this the standardization of practice. The amount appropriated for public utilities is $85,000 and it ought to be $250,000 Our estimate next year would probably be $250,000. For Radio research we have $30,000, we have a special building for that work. Our military department, our navy department, and two or three other departments are using radio, and so the Bureau undertakes scientific investigations that have to do with radio communication. The fund for that is $30,000, but it ought to be ten times that amount. To-day telegraphic communication and cable communication are just about what they were years ago. The war has stimulated progress to a large extent, but the methods of cabling have not advanced much and the cables are idle for a large part of the time. There is therefore a most urgent need for the development and improvement of these methods of communication. There is no reason why the telegraph should not take the place of the mails to a larger extent, but it must be done by methods of transmission, making it possible to transmit messages much more quickly.

Then there is colour standarization. The industries are very much interested in that. Many of the products, such as cotton seed oil and other materials of that kind depend for their value on their colour. We have developed a method of referring colour to the spectrum colours and making it in such a way that the manufacturers can use it. The fund for that is $10,000. I am giving you these sums that are appropriated for the investigation of problems in a particular field. Some of these will be appropriated for a year; some are appropriated continuously for a period of four or five years. Then there is a sum of five thousand dollars for investigating physical constants. That is a very important matter in connection with all sorts of industrial work. They must use melting points, the conductivities of materials for heat and electricity, and the constants used by engineers in all sorts of work. Most of these constants were determined years ago, some of them fifty and a hundred years ago. A great many of them need redetermination. They are just as important in engineering work as yard sticks and so on. Let me give you an illustration. Congress gave us $15,000 annually for five years to determine the refrigerating constants. The refrigerating industry was badly in need of such things as the specific heat of brine, the latent heat of ice, the boiling point of ammonia, and the latent heat of ammonia. These are ordinary data that they had to use. These constants were determined very carefully and accurately, and several of them stand as classical productions in that line of work. Some of them are just as useful to a steam engineer

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as they are to a refrigerating engineer. I think the determination of physical constants is provided for in your bill, as it should be.

Then for mechanical devices there is a fund of $15,000. One interesting feature is that the Post Office authorities are endeavouring to prevent the use of the mails to promote frauds. They do not allow the use of the mails for this purpose. I do not know how it is in this country, but in the States there are many people who live by the promotion of fraudulent devices, and the Post Office referred many of these questions to the bureau of standards. Every industry has its patent medicines. Take the cement industry; millions of dollars have been put into materials which added to the cement are supposed to make it waterproof. It has been shown clearly by experiment that the cement if properly mixed and installed, is impervious to water. The country is flooded with things to put in gasoline to give it more power. They have even gone to the extent of professing to make fuel out of water. The number of electrical devices for medical purposes is simply enormous. There should be an institution where any government bureau or the public can go and have a proper answer in regard to these things, to obtain proof or disproof, and the stamp of disapproval in many cases is as valuable as the stamp of approval.

Mr. GLASS: Are they obliged to submit these devices for approval?

DR. STRATTON: No, I do not think it would be wise under our form of government to compel them to do so at present.

During the war we put over half a million dollars into the standardization of guages for munitions. Manufacturers are not going to give it up. They are going to retain that method. We will put into it $40,000 or $50,000 and make it possible for any manufacturer to bring his master guages to the bureau to have them standardized. These guages were tested very largely by the block guages imported from Sweden. If a manufacturer wished to test a pair of calipers to measure three inches, or a set guage, he could build up three of these inch blocks and set them in the caliper. We depended formerly on the imported guages, but during the war a method of making these guages was discovered and there you have a splendid illustration of how the application of science which I will describe. There were two or three lines in the work in the Bureau that we felt would have no practical military application, and we thought of dropping them during the war. One was a method of measuring lens by means of light waves. For many years there has been a desire to have a natural standard of length that could not be destroyed. The problem was solved by the light waves. The wave rays are very short, about a fifty thousandth of an inch long as an average, but definite waves of a constant length can be produced. The method of using them is difficult. You would find it very hard to measure distances, by counting the divisions on a steel tape with no minutes on it. That is what is meant in the case of light waves. But we have gotten beyond that now. When these standard blocks or end standards were developed we had to test them. We found it practically impossible to compare them with the length standards of the bureau. The original standards, metric or common, are bars with lines defining their ends, whereas these in question are bars with two flat parallel ends, and you test the calipers or guages over the ends. The value of the metre in light waves was established twenty years ago, and we know the relation between the yard and the metre. We measure the standard blocks in terms of light waves, and we can translate it into inches or centimetres just as easily as you can translate pounds into dollars and cents. It is possible to test the guages by this method and test them quickly. They have never been compared with any material standard of length; that is a great improvement, and it has turned out to be one of the most valuable things in munition or industrial work and will have a lasting effect. We can depend upon the light waves as a standard of length. The late Sir David Gill, an eminent British astronomer, advocated this proposition, and it only lacked the proper trial to have it adopted. It is now demon-

strated beyond a doubt that the light wave is a reliable standard. If all the metres and yards were destroyed to-morrow we could go on with this work.

The mine scales investigation cost $15,000. We found that the track, elevator, and mine scales were very poorly installed, and great errors occurred because the scales are so large you cannot take them to a particular place. We have three test cars, of 100,000 pounds each. They go over the country along the railroads and test these large scales. One very serious case was that of a mine scale where the workmen were being defrauded out of a large part of their wages, because the scales were fraudulently used, but in most cases the scales were incorrect simply because there were no facilities for testing. It is not an easy matter to test a 100,000-pound track scale. It requires a good deal of work to get the weights to do it with, and they must be transported over the country.

Then we have metallurgical research fund $25,000. That has to do with a great many important metallurgical problems, also the industrial pyrometry fund. Very nearly everything here could have been carried on with our regular appropriations, but they were insufficient. Each one of these special funds represents some particular group of work that ought to be emphasized and put through quickly. With regard to industrial pyrometry, we will develop pyrometry more rapidly than we have before. That is high temperature measuring in the industries. There are several of these methods, but I will not go into them.

I want to say something in regard to the relation of this work to the industries. In the first place the various industrial representatives asked almost the same questions. They can be grouped around certain classes of experts in definite fields of physics and chemistry. The relation of this bureau to the industries is, first, in connection with standards of and the methods of measurement, these are essential in all commerce and industry. Secondly, it helps the industries to solve their problems. The policy of the bureau is rather to help industries to help themselves. We take up only those problems which are a benefit to an industry as a whole, and someone is sure to ask the question, "Why not let the industry do that themselves?" If you confine the work of such an institution to the problems which the industry as a whole needs, you have done it in an efficient and economical way. What is the use of a hundred units of industry working out a thing that can be done in one place? Furthermore, these industries have all they can handle in problems which are specific to their own work. If we furnish them with the standards and with the general underlying results of scientific work, they will assist in applying them. They will take it up themselves and they will establish their own research laboratories and do what they never could have done before. In other words, this institute will be the leader of all those laboratories. It will be the clearing house for certain kinds of knowledge, and it will lead these people to do for themselves what they never could do otherwise. I think that is the greatest value that comes from such an institution.

Mr. NICKLE: One of the professors of the University of Toronto, in giving evidence before the Committee, stated that for a number of years they endeavoured to stimulate post-graduate work, but ultimately they abandoned it because they found that all their best men went to the United States, and that there was no demand among the manufacturers and producers for highly trained men. What would you suggest, by propaganda or otherwise, as a means of stimulating the appreciation of the manufacturers in this country to insist on the application of scientific research to industry?

Dr. STRATTON: I think the establishment of such an institution is the first great step in that direction. Let me finish this point and I think it will answer your question. Many industries are unaccustomed to going to a university for some strange reason. There is a very wide gap between them and the university. A great

[Dr. S. W. Stratton.]

many university professors have not yet arisen to the importance of this problem. The manufacturer does not think he can get help at the university very often when he can. Even in our own case he has heard of the Bureau of Standards but he does not think it can assist him in a general way. However, he often comes to it much in the same way that the man will go to the dentist when he has the toothache, he is in trouble about some particular thing, usually a standard or a method of measurement or he needs a material with certain properties. When he comes to us we help him. We say nothing about his work, we simply do what he wants us to do, but he has become interested and he wants more, he begins to look around, and soon asks himself this question, "Why can I not do something of this kind?" And we have established relations with him. That is part of the answer to your question and the other is that we try to anticipate the needs of an industry very largely by working through its organizations. I presume it is the same with you as with us, that your industries are all organized. We have an iron and steel institute. All the steel men belong to it. In the ceramic industry they have several associations of men in the various clay products and they may want assistance. We work with these associations, and we ask them to appoint research committees. Nine times out of ten our contact arises through our own people taking an interest in those associations. Our ceramic and clay product men on the bureau staff are members of these societies; they find out these problems and take them up. The day is past for these units of an industry to work alone. One of the greatest things that is done in these industries is getting together. They put their problems on the table and discuss all matters of common interest; they have gotten beyond trying to fight each other, and they unite in the solution of their problems; this is only one special instance of it. They will soon learn to come to you with their troubles.

Mr. NICKLE: I do not think our industries are as closely co-ordinated as yours. We have one large manufacturing association, but they are not co-ordinating with others.

Dr. STRATTON: Start on that and the others will follow. Our experience is that as soon as you establish contact with an industry others will follow. It does not always mean doing a thing by the Government. Members of Congress sometimes say that they do not want to develop a paternal government as in Germany. My answer always is: "Of course not, but we do want to develop a fraternal government."

Now as to the relations of such an institute to the public, you would be surprised at the great amount of good that it can do in that direction. The public do not understand many of these things, especially in their dealings with manufacturies and industries. Even in regard to labour problems, you would be surprised at the number of questions that come from the labour side as to whether this should be allowed or not, and whether it is safe to do this or that. We are just as anxious to give them the right scientific knowledge as we are to give it to the manufacturer. In fact, if both sides knew the right thing, knew the truth, we would have few differences. This is especially true in the economic and efficient use of materials. We are undoubtedly very wasteful in the use of materials. We ought to know where a certain thing can best be used, and if we could only educate the public up to the things they ought to have or do we would save an enormous amount of waste. We are issuing some circulars along that line intended to educate people in matters of the household. It is a mere by-product of the bureau, but it is a saving of knowledge that would otherwise be wasted. One deals with weights and measures in the household. Another has reference to safety. Another deals with materials in the household. We have tried to put some of these things in simple terms so that the person in the ordinary walks of life can understand them. These circulars are very popular. There are merely by-products that are of value.

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Mr. GLASS: How is that information diffused among the public?

Dr. STRATTON: Through publications. When a publication is issued, copies are sent to the technical press. The technical press is pretty well organized in the States. If, for example, a publication is issued giving the results of an investigation in regard to a clay product, there are half a dozen papers that will publish abstracts of it, and we send the information to them. We do not have any free distribution except in the way of those popular circulars that I have referred to. We have not the slightest difficulty in getting the scientific and technical press to publish these abstracts. They are glad to do it, and we get requests for them. Individuals wishing further information request the publication of the bureau. Some of the more expensive publications are sold. When we wish to carry on propaganda among the public, we take the initiative and distribute some of these publications. That is a question that you will have to consider, the question of how best to bring the results before the public.

I wish to emphasize a matter that does not seem to be directly provided for in your bill; that is the relation of such an institution to your other government activities. Generally, government departments are carrying on a number of technical lines of work. You have your various Surveys, I presume, and there are others. Such an institution as that proposed is available for the Government departments and will increase their efficiency just as much as it will increase the efficiency of an industry. Our own institution could be applied with great profit to government work alone.

Every technical department of the Government has a certain thing to do, and the tendency of Government institutions is to do it themselves. That is largely because they cannot get it done elsewhere. Our Surveys comes to us for the standardization and testing of their standards and for many pieces of apparatus. That enables them to use their own forces along other lines, and gives them the advantage of correctness and uniformity. The same is true of other technical departments. There is not one that will not be involved in scientific or technological work, and they will use the institution just as the public does.

Mr. GLASS: Does the Bureau do work for such a department as the Department of Mines?

Dr. STRATTON: The Bureau of Mines cannot go into testing of the instruments for measuring the heat values of fuel and so on. The measurement of the heating value of fuel is a problem for a physical laboratory. Take illuminating gas. Its value depends on its heating value. We have almost abandoned the light standard of gas. It is a difficult matter to measure the heating value, it involves standards and methods of measurement in heat; such problems must be solved for the public and for manufacturers, and the efficient way to solve them is to have one place to work them out. You could not have brought up a better illustration. Take our coast survey. It used to spend a great deal of time in the testing of its base measuring apparatus. It had to do so. Now we test them just as we do for manufacturers or for anybody else. I could give you any number of illustrations of our government work, particularly in regard to these departments of the government that are involved in the use of electricity, the distribution of power, and things of that kind. The legislative branch of your government will find the institution invaluable.

Mr. NICKLE: In connection with your Government, the various departments that carry on investigation work, carry on their own work, making use of your constants?

Dr. STRATTON: Yes, their own technical work. There is another point that I desire to bring out and one which I do not see emphasized in the Bill. That is the placing of government purchases on a proper basis. I made an investigation some ten or twelve years ago and I found it took several pages of large paper to detail the number of varieties of pencils that were used by our Government departments.

There was no co-operation between the various departments. In other words, there was no standardization of these things. What is even more important than that is the specification of standards of quality, I presume your Government is engaged in construction work of all kinds, involving the use of many varieties of building materials. There is no reason why these specifications should not be uniform and the best. In the case of cement we found that in the various government bureaus they were using different specifications. That made it difficult to test it at the Bureau of Standards. The first step was to get them to adopt a uniform specification for cement and its testing. Our supervising architect had a specification which stated that the magnesia content should not be more than two and nine tenths per cent. He could not tell where he got the specification or the reason for it, nor could we get him to change. We called together the representatives of the Government, and agreed upon a specification as far as we could, but there was this one outstanding point, we found it necessary to construct a small cement mill to investigate this point. We burned the material there varying the magnesia cement of from 2 to 6 per cent and we showed that up to 5 per cent it was perfectly harmless, but that was insignificant as compared that the fact that we could give this knowledge to the public; serving in an advisory capacity to the Government results in a great saving but the value of our work in connection with Government standardization to the Government is insignificant as compared with the value of giving this knowledge to the public. There is another thing; do not overlook, namely, the importance of such an institution in serving the Government in an advisory capacity your legislative bodies in matters pertaining to scientific work. It is a fact that legislation is too often based upon wrong scientific principles, there is no class of people who need more, a place to go for scientific facts than those engaged in the preparation of laws or regulations.

In State and even national legislation we found a great many cases of the incorrect use of terms and scientific laws in view of the lack of proper knowledge of scientific facts and scientific terms, this institution will be of the greatest service in ordinary legislative work. The day before I left a question was referred to us by the Ways and Means Committee of the House of Representatives, and it is a common thing for that or the other committees to refer to us with regard to scientific facts in connection with proposed legislation.

A locomotive in going from New York to Chicago would meet with a different law regarding headlights in each State; some of the State laws were monstrosities, and not a single one of them was based upon correct scientific principles. That arose from the fact that the men charged with legislation thought that something ought to be done but did not know how to state or define the action of the headlight in proper terms. It is amazing the amount of good that such an institution can do in the preparation of legislation alone.

Before closing I would like to state another reason why the industrial man has not applied science as he should, and why the scientific man has not gotten as close to the industrial side as he should, I refer to the great gap that exists between the scientific investigator and the manufacturer. Take the case of the cement cited, if the manufacturer had undertaken to perform that experiment it would have cost him thousands of dollars, because his mill was a large mill burning many barrels per day, and to vary his product is a very serious matter. On the other hand the scientific investigator in his laboratory is entirely unfamiliar with the production side, he has not the variety of materials at hand with which to work; in the case in question we put in a small mill as stated before, and that enabled our scientific men to have before them the samples they needed for investigation, that is of the utmost importance. I cannot emphasize this too strongly. Next we put in a small paper mill. The paper manufacturers said that we could not succeed in standardizing paper, that there were no good methods of testing it, and I said, "All right we will develop them," the manu-

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facturers said we could not make paper, but we got the mill, it makes a sheet of paper 30 inches wide and we succeeded in making the samples needed. Those are our methods. We can vary the product in that mill. At first manufacturers claimed the specifications of the Government were not correct. We made up the paper in some cases and found out where the limit should be drawn or when the specifications could be improved. You could not utilize a large mill for that purpose, because it would stop the progress of the whole factory, we have bridged that gap. We think no more of operating that mill than of using any other apparatus, it has paid for itself many times. The manufacturers said to us, "Where did you get that mill? We want one like it." And now there are several similar mills. A very short time ago the Siamese Government got the specifications for one to be sent over to Siam. Next followed small mills of other descriptions, they are pieces of laboratory apparatus, and the laboratory man's field is broadened, he has the means of producing the material he works with. As soon as the manufacturer sees that you have something and that you know what you are talking about, he is only too willing to co-operate, because it does not mean the stoppage of large plants. We have recently added in our metallurgic work a 16-inch rolling mill. A few days ago I addressed the Iron and Steel Institute in New York, and I hesitated somewhat about showing them the picture of this machine. I was afraid they might think it was a little presumptuous on my part, but I did show it and the result was great applause, and we have had inquiries since as to where they could get such apparatus. The purpose of that mill is in connection with the investigating of metal and their alloys, there is no more important question in metallurgy than that of alloys. A little tungsten or zircomum or some other substance completely changes the character of the steel, and the steel has its character changed by its mechanical treatment. The alloy has to be made up and rolled and hammered, and treated in the way these things are ordinarily treated in the factory to see what these properties are. You must have furnaces and hydraulic presses in order to make these experiments with metals. The industries are asking us to help them do things which they have never done before. There is one very serious question which is arising. These industries will find in coming to you that this or that man is just the one they want, and they will try to get him. We have had some of our laboratories almost completely stripped of scientific men in the last year or two. This is largely due to the fact that there is no place, or very few places to-day in our country or yours where the educational institutions are equipped for turning out men prepared for technical work. It is not entirely within their functions. We want men for this work and the industries want men who are thoroughly grounded in physics and mathematics, this our universities can do, but unfortunately these fields are not looked upon by students as professional fields. Something should be done to encourage the study and teaching, especially of physics, chemistry and mathematics; if the universities will turn out men well grounded in these subjects they will be taken up rapidly by the industrial concerns of this country; that to-day is one of the greatest essentials in doing this sort of work. Such men can be trained by the technical schools by the institution you propose to establish and by the more advanced industries in the methods of research as applied to the industries.

Mr. NICKLE: Can you elaborate on the question as to how the universities should be encouraged?

Dr. STRATTON: There are a number of ways. The average boy when he goes to college has no idea of physics or other sciences as a profession. He ought to be taught that earlier in life. He does not know of these great opportunities along industrial lines, or that there is a demand for scientific men. Of course, most of the young men who go to college and have a leaning that way are thinking of engineering and take it up. The great demand in the past has been for engineers, they know little of these other fields. The remedy must be to popularize that work and make it known to the

young people starting out in their college work. The universities should recognize such fields exactly as they do engineering.

Mr. NICKLE: After these men become thoroughly proficient in the University of Toronto, it seems they are going to be taken from this country, because there is no opportunity for reasonably remunerative work in Canada?

Dr. STRATTON: You need not give that a second thought. It is the other way at present. You are calling for our men. There are not enough of these men trained in fundamental science in both countries to satisfy one or two of the large institutions.

Mr. NICKLE: You think the time has come when there is a stimulative demand for these men?

Dr. STRATTON: Worse than that, and if the present demand continues we will have very few teachers left in our institutions, that is a serious matter.

Mr. NICKLE: Can that be remedied by the granting of scholarships?

Dr. STRATTON: It should be done by raising the salaries of the scientific men, so that the universities can hold the best men as instructors and by granting scholarships to students. The universities must give these students better opportunities for research work, and make it worth their while, they must turn out students who are taught how to investigate. That is the main thing. Men are wanted, first of all, who are thoroughly grounded in the fundamental sciences. I always think of physics, chemistry and mathematics, there should be added technical courses in graduate work, the universities should prepare themselves for some of these things. They could turn out men trained in cellulose chemistry, in chemistry of rubber, etc. That is what the industries want. It does not mean a departure from classical science, because these things mean scientific work of the most advanced and difficult sorts.

Mr. NICKLE: You look upon the universities as the source for the supply of these men?

Dr. STRATTON: Yes, that is the weakest point in this great problem—the supply of men skilled in the methods of applying science.

Mr. NICKLE: Do you think it is practicable in this country, where up to the present there has not been much demand by the manufacturers to carry on independent research work to incorporate the Mellon Institute idea with the Bureau of Standards?

Dr. STRATTON: That can be done. Very often the smaller units of an industry will advance and do something of that kind. Personally, I would like to see a government institution confine its work to those problems which give the information needed by the industries as a whole. In some cases it is probably wise to provide for the small unit in some specific investigation; but on the whole, the units of an industry will sooner or later have their own technical men and their own small laboratory and handle those problems. You will have to do both things, but especially the great fundamental problems.

Mr. NICKLE: You think that the tendency is to allow industries to establish their own laboratories?

Dr. STRATTON: To certain extent. You cannot do everything for the manufacturer; you want him to help himself. There are certain problems that come up in relation to his own industry, and to solve them successfully he ought to have the necessary facts. You do not want to interfere with their independence, you want to encourage them to improve their processes, but in this they need leadership and help.

Mr. NICKLE: In the Bureau of Standards you conduct research work along the line of pure science, as well as along the more narrow line of applied science?

Dr. STRATTON: Yes, but it is difficult to draw a line between pure and applied science.

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Mr. NICKLE: You make no distinction?

Dr. STRATTON: Not much. Some of these problems that come to us from the industries are most difficult, and involve the most difficult questions in physics and chemistry.

Mr. NICKLE: The pure science of to-day is the industrial science of to-morrow?

Dr. STRATTON: Yes, they can go hand in hand. The main thing is to educate the industries as to the value of science, and as to doing things better than they have done them before. This institution is just one of the many factors. Your educational institutions will have their own problems. I do not know how it is in this country, but in the United States the educational institutions are provincial, that is, supported by the various states or private endowments. They are getting greatly interested in this work. There are always enough problems of local interest with which they can deal, and there should be no conflict between this institution and the educational institution. This institution will help every university to do better work. In the old days, and even now, many workers in the university engaged in problems which involve say the precise measurement of temperature, spend three-fourths of their time in doing work which they could get done at the bureau you propose to establish for a few dollars or even free. It is marvellous how such an institution will help a university to do its research work better.

With us, and I presume it is the same with you, the need is to divert some of the coming generation of college men to work of this kind so that more men may be turned out for the scientific work. I should say that the supply to-day was about one-tenth of the demand, not more. I do not believe that enough real investigators in scientific fields are being turned out to satisfy the needs of the General Electric Laboratory alone, and I am sure that the Bureau of Standards could absorb every one of them. This institution will have a very great effect upon your educational institutions. It will stimulate research in them rather than work against them, and in turn the educational institutions will provide more men for scientific investigations both in the educational and industrial laboratories.

Mr. GLASS: You spoke of the development of ceramics in the United States, and you said that there were materials there that were not being properly used. We have in this country large deposits of clays which are made into sewer pipes that are said to be vitrified, but are really porous, and the sewage escapes through the pipes into the soil. What vitrification is defined in your Bureau?

Dr. STRATTON: If any of your units in this industry will take the trouble to go to Pittsburg and confer with Doctor Blemnger, our class expert there, he will be delighted to help you along that line. The trouble arises largely from the fact that the manufacturer is not inclined to use a substitute, that is to leave out one thing and put in another. Take the question of kaolin for pottery and other ceramic work. We have been importing the English kaolin. Our own is just as good, but it must be treated differently; a substitute cannot always be used the same as that which it replaces. If we had built up our ceramic industries by using our own materials it would have been better. A substitute involves a proper knowledge of its characteristics. You have to learn how to use a substitute, and that would be an important function of your institution.

Mr. NICKLE: What is the legislation of the Smith Howard Bill?

Dr. STRATTON: I do not know, there has been so much difference of opinion with regard to it. That was originally an effort to get additional assistance for the universities, to establish engineering experimental stations. Most of the universities have them already, but it would undoubtedly help the smaller schools to undertake research work. We have two kinds of State institutions, the land grant colleges, and

others. They have not been able to agree as to which institution in each State should have this assistance it is proposed the national government should give, but that is not of much consequence.

Mr. GLASS: I want to ask you a question with reference to the development of the flax fibre industry for textile purposes. The growing of flax is an important industry in the western part of Ontario, and we have had some demonstration and some information in regard to the development of the flax fibre industry, and the desirability of establishing a textile industry in Canada. I understand that your Bureau of Standards has been doing some work in this connection and that the process has been developed by which the flax fibre might be produced at a lower cost than cotton and that in the demonstration which was made it was shown that the fibre produced by the Bureau of Standards' process was far superior to the other.

Dr. STRATTON: I think that was overdrawn. This concern did come in with a chemical process that was satisfactory, and made fibre as good as by the ordinary process. I understand they were prevented from developing it by the serious conditions brought about by the war. It was attempted to grow flax in the Western States; we grow a great deal of flax for the seed, when it is grown for seed it is altogether different from what it is when used for textiles. It is a very promising field. Do you manufacture any now?

Mr. GLASS: We manufactured 3,000 tons of fibre last year.

Dr. STRATTON: Have you spun and woven it yet?

Mr. GLASS: The Government gave a bounty for spinning yarn from Canadian flax.

Dr. STRATTON: That is a splendid thing to do, it is a new industry that should be welcomed in both countries. I want to give you one illustration of how such things are worked out. Just before the war we were developing a large aviation programme, and somewhat suddenly it was discovered that there was not enough linen to cover all the planes, the question was immediately asked whether anything but linen would do. The Bureau of Standards had been working, and contemplated the use of cotton fabric made from long staple cotton. We anticipated this need for cloth, to cover the machines, we got out the specifications for cloth and went to the mill to have it woven, by the time they discovered this need we had a sample ready. Now we use cotton in our aviation, and the British Government is also using it, last year they all used cotton and that relieved the linen industry.

Mr. MCGIBBON: Were they just as good?

Dr. STRATTON: Just as good or better.

Dr. MACALLUM: In a public meeting at Montreal, one of the speakers made the statement that the Bureau of Standards did not do actual research work, that it was not for scientific research. I would like to have a statement made by Dr. Stratton here in reference to that.

Dr. STRATTON: The Bureau does work on scientific research, you cannot separate the two branches, you cannot standardize the material without making scientific research.

Dr. MACALLUM: It is a scientific bureau.

Dr. STRATTON: Absolutely, one of the best equipped scientific laboratories in the States.

Dr. MACALLUM: The statement was made that the scientific work published by the Bureau was simply a report of work carried on outside the Bureau by other organizations.

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Dr. STRATTON: We have never published a single publication, to my knowledge, of work carried on outside the Bureau. There may have been one or two instances where the man began work while at the Bureau and afterwards left it, and we asked him to finish his work, the results were published by the Bureau.

The ACTING CHAIRMAN: The reason why there is some opposition to this proposed enterprise I understand is, that if the scientific research institute were established in connection with the Bureau of Standards the fact that a man who is engaged in scientific research has to sign a book, or punch a clock at a certain hour and go at a certain hour for a certain number of dollars per month would have a dampening effect upon his ardour as a scientist.

Dr. STRATTON: The conditions are exactly the same as those in any scientific laboratory.

The ACTING CHAIRMAN: How do you handle that at the Bureau of Research at Washington?

Dr. STRATTON: With regard to the genuine scientific man who has his work at heart we are more concerned in keeping him from killing himself by overwork than about the punching. The labourers, the minor assistants and the people of that kind you have to check by some means, but we keep a record that places no restrictions upon the scientific men, and by these records we find that a very large majority of them put in overtime, too much overtime occasionally. The restrictions at the Bureau are no more severe than in any educational institution. Our hours of work commence at 9.00 o'clock and end at 4.30, we have no trouble with the scientific investigators, if they find it necessary to work at night or in irregular hours they do so; of course you never know, it may be that has been abused, and will be probably, by assistants and people of that kind; we must have some system, but we have a flexible one, we put these people upon their honour.

Mr. MCGIBBON: There has been a suggestion made that instead of having a Central Research Bureau here in Ottawa we should divide it up between the different universities, what do you think of that?

Dr. STRATTON: The business of the two institutions are entirely different. The university's business is to turn out men, trained men, there must be a certain amount of research work done to train them. But this is a different thing altogether. As stated before I think this will encourage and help every university, it will enable the universities to do much more than they did before. We found it so, it standardized the instruments used in the universities. I have never heard a complaint about doing the work they ought to do. In fact a new question has arisen within the last few weeks; a few of our leading organizations of industrial men have asked us if they cannot send men to the Bureau for this intermediate training. They must of course be college men who have finished the college course, these manufacturers want them to work in the Bureau in order to fit them for investigational work. The question is up to-day, as to whether or not they can send these men; they have asked us to state the conditions under which they can send them.

Dr. MCGIBBON: Do you think Dr. Stratton, that it would be possible in training to provide regulations for such an institute to put down some scheme that would bring together in closer co-operation all these factors, this institute and the industries and the universities.

Dr. STRATTON: I do not see how you can put it down, but it will work out that way. You have your functions there which are very well stated. It depends largely upon the personnel, too, and the attitude of the people in charge towards the industries.

Mr. McGIBBON: As the function of this Committee is to make a report to Parliament and to embody something more or less concrete, could you give us an idea of the cost that would be required to start?

Dr. STRATTON: I do not know what provisions you contemplate making. There is this to be kept in mind: That it will take about twice as much to start with as it would ten or fifteen years ago, but it is better to start on a modest scale for many reasons. You will have to cultivate a connection with the industries gradually. You must give the universities a chance to meet this new demand for men. If you could start a bureau such as ours to-morrow, if it were possible to place instantly all these buildings and equipment here, you could not man it. You will have difficulty in manning it in any event. It will give it a reasonable start if you have half a million dollars or so for the first building, draw up the plan in such a way that it can be extended from year to year, I think you will meet the situation. It will take a year or two years to prepare the plan and erect the building and get the bureau operating. In the meantime some work can be done in temporary quarters. We usually count upon about half the cost of the building for equipment. That does not come in the first year always. I do not mean the heating and lighting, but the scientific equipment should be about half the cost of the building. Sometimes it is more and sometimes it is less. It depends on the nature of the work. The main thing at the start is to have one or two buildings of the style or type you propose to perpetuate, and have a few good men as leaders, men who have the breadth of vision, and who can plan this work for the future, as an architect could plan a building, and have these men supplemented by such assistants as you need. Unfortunately, we had to commence at the other end of it in many cases. We had to take a man out of college and put him in charge of work, and then tell him to find out something about it.

The ACTING CHAIRMAN: It has taken eighteen years to reach your present state?

Dr. STRATTON: Yes.

The ACTING CHAIRMAN: In describing your plan you said you began in a small way.

Dr. STRATTON: Yes. That is the proper way to do.

The ACTING CHAIRMAN: Were you connected with it then?

Dr. STRATTON: Yes, I helped to draw up the original bill.

The ACTING CHAIRMAN: Do you recall how much your original investment was?

Dr. STRATTON: $250,000 for original buildings and $100,000 for equipment, and a staff of 14 or 15 people, the first year. It would take twice the amount now on account of the rise in the price of things. You should take advantage of our experience as far as possible and also of the experience of the British National Physical Laboratory. There is no use in going over the ground we have traversed, but begin where we left off. I am convinced after 20 years of experience that all the money you can put in this up to a point where it can be efficiently handled and properly administered, will yield greater returns than any other money you can spend.

Mr. McGIBBON: Can you tell us how to convince members of Parliament on that point?

Dr. STRATTON: That is what I am trying to do.

Mr. McGIBBON: I mean the members who are not on this Committee.

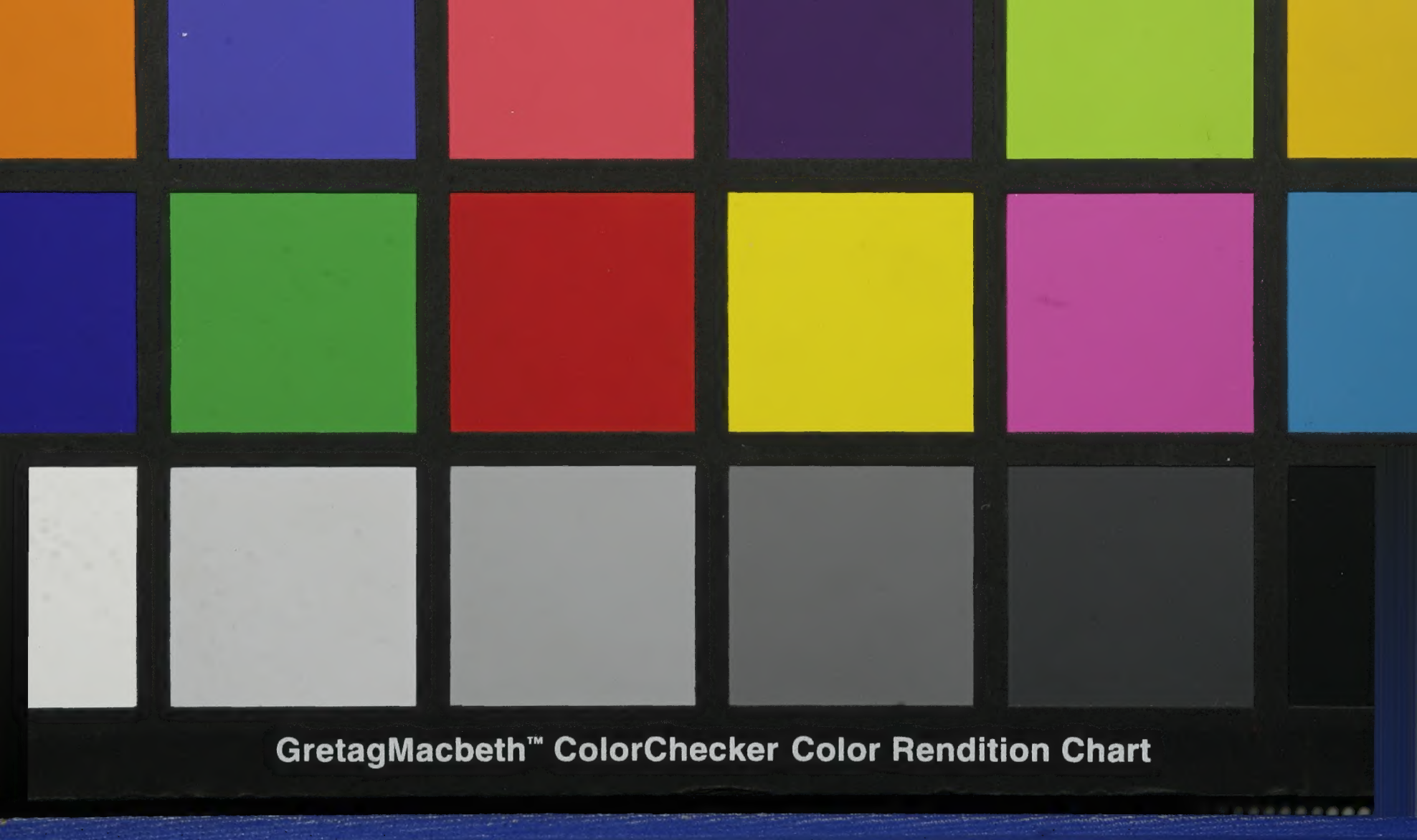
Dr. STRATTON: Parliament usually adopts the report of a Committee, does it not? I think the thing to do is to educate a few of the leaders, the more the better. That was done in our case with five or six members. Make them thoroughly familiar with the proposition and what it means, and they will advocate it on the floor of the House. Of course our system is entirely different. The members of the Government cannot

go on the floor and advocate a measure. It must be done through the members of Congress, in fact it would be well to prepare a concise and clear statement of what the institution is for in language the layman can understand.

I hope that if your institution is established, those who have it in charge will take advantage of our experience, we will give you everything, not only along the line of our successes, but also along the line of things you are not to do. We ought to do everything possible to cultivate good relations between the two countries.

The ACTING CHAIRMAN: In the name of the Committee and of Parliament I thank you for your interesting and instructive address, which I think is going to be of great benefit to the Committee in regard to advising the Government as to the course we shall pursue in Canada on this very important matter.

The Committee adjourned.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